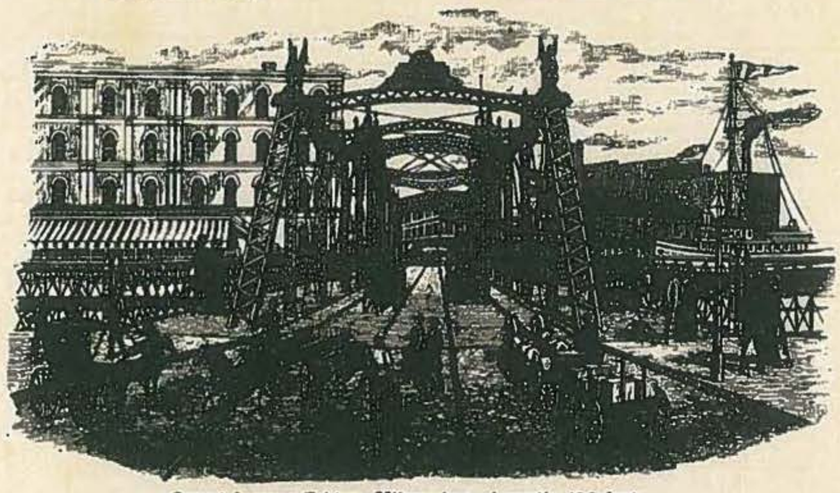
HISTORIC HIGHWAY BRIDGES IN WISCONSIN

Volume 2, Part 1

MILWAUKEE BRIDGE AND IRON WORKS.

FOUNDED 1870. INCORPORATED 1887.



Grand Avenue Bridge, Milwaukee.—Length, 180 feet.

Office and Works, Corner Fowler and Seventeenth Sts., Milwaukee, Wis.

Wisconsin State Gazetteer and Business Directory, 1888-1889

TRUSS BRIDGES

1998

WISCONSIN DEPARTMENT OF TRANSPORTATION

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PREFACE

This report presents the results of a survey of metal-truss highway bridges located on or over public thoroughfares in the State of Wisconsin. Prepared for the Wisconsin Department of Transportation (WisDOT), the study is intended to assist the agency in fulfilling its historic preservation responsibilities as mandated by the National Historic Preservation Act, the Department of Transportation Act, and related amendments, laws, and regulations. To this end, the report focuses on the identification, documentation, and evaluation of significant metal-truss highway bridges within the boundaries of the state.

The report builds on and completes the work initiated by the Historic Bridge Advisory Committee (HBAC). HBAC was established in 1981 by WisDOT to conduct a statewide survey of historic bridges. Composed of members from the University of Wisconsin-Madison's College of Engineering, the Federal Highway Administration, and the State Historic Preservation Office, HBAC focused on metal-truss bridges.

Although the truss-bridge category was the first to be studied in Wisconsin, it is the second volume in the series, "Historic Bridges of Wisconsin," and the third to be published. The results of the statewide inventory of stone-arch and concrete-arch bridges were published in 1986 as Volume 1, and the results of the statewide inventory of movable bridges was published in 1996 as Volume 3. In the same way that the previous publications have been found to be useful tools for assessing the significance of Wisconsin arch bridges and movable bridges, the present study is intended to provide a reliable historic context for the state's metal-truss bridges.

Part 1 of this volume includes five chapters. Chapter 1 outlines the survey project's background, objectives, and methodology. Chapter 2 provides a historical overview of Wisconsin truss bridges, including discussions of their design, materials, fabrication and erection. Chapter

3 explains the important role of the State Highway Commission (SHC). Chapter 4 furnishes a brief history of known prolific bridge builders within the state. Chapter 5 discusses the issue of the aesthetics of truss bridges. Illustrations, footnotes, and a bibliography supplement the text. The Appendix, Part 2 of the study, contains field-survey forms and illustrations of 55 bridges surveyed in 1986 with status updated through 1996.

This study is based largely upon the results of previous work of the HBAC, which met from 1980-1986, and resurvey and completion of intensive survey forms for 55 truss bridges by Jeffrey A. Hess and Robert M. Frame III, under contract with WisDOT. WisDOT staff historian Robert Newbery served as project manager for the survey. Chapters 1 - 4 were prepared by Robert Newbery. Chapter 5 and the edit and layout of this volume were completed by Amy R. Squitieri, Christina Slattery, and Kirk R. Huffaker of Mead & Hunt, Inc.

Special thanks are due to the many people at WisDOT and the State Historical Society of Wisconsin who assisted in various ways in this study. In particular, Harvey Anderson, Wayne Kerwin, and Jim Pautsky of the WisDOT Bridge Section deserve special notice. Stan Woods and Craig Worley also provided useful assistance. Rick Dexter of the SHPO has been supportive throughout this project. Kim Peters and Diane Filipowicz, former SHPO staff members, were valuable in the early stages.

CHAPTER 1

BACKGROUND, OBJECTIVES, AND METHODOLOGY

Traditionally, the appeal of historic bridges has been limited either to local history buffs or to a fairly small circle of architects and engineers. The first group's interest often reflected a kind of generalized nostalgia, extending equally to old bridges, old oxcarts, and old gristmills. The second group's appreciation tended to focus on aesthetic concerns, spotlighting historic bridges as examples of "pure structure" that "provide an unequaled opportunity to examine the historical development of design, construction, and analytical methods."[1] For the most part, the public was oblivious of either camp. When it thought about old bridges at all, it generally regarded them solely in terms of convenience and safety.

In the 1970s, however, bridges attracted the attention of the nation's historic preservation movement, which served to combine and broaden the nostalgic and aesthetic interests of previous bridge enthusiasts. Preservationists also began producing new scholarship on the role of bridges in the history of engineering, technology, and transportation. The impetus for this increased public awareness came largely from federal legislation requiring historical evaluations of all bridges scheduled for modification or replacement with federal funds.[2] As it became evident that case-by-case evaluations frequently delayed highway construction projects, various states mounted statewide bridge surveys. Since metal-truss bridges generally were the oldest distinctive category of historic bridges, they often were the focus of these first statewide studies.

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[1] Emory Kemp, "Exemplars of Engineering," Science 16 (May 1980): 727.

[2] William P. Chamberlin, Historic Bridges—Criteria for Decision Making (Washington, D.C.: Transportation Research Board and National Research Council, 1983) 10-11.

Two of the earliest historic bridge studies were conducted in Virginia and Wisconsin. Virginia was the first state to begin a thorough and systematic survey of truss bridges, and its work established standards for other states. Beginning in 1973, Virginia published eight volumes relating to historic truss bridges.[3] In particular, Virginia pioneered in the development of a numerical rating system to evaluate the historical significance of truss bridges and to determine their potential eligibility to the National Register of Historic Places. With various modifications, this system was adopted by several other states, including Wisconsin.

The Wisconsin study, initiated in 1976 by the State Historic Preservation Office (SHPO), was the work of historian George M. Danko. Danko produced two volumes that did not receive wide distribution.[4] Based on an extensive literature search, the first volume traced related developments in engineering, metallurgy, and manufacturing to provide a general historical overview of truss-bridge design and construction on both a state and national level. In 1977, Danko conducted an intensive field survey of truss bridges in 11 Wisconsin counties (see Figure 1). Using the records of the Wisconsin Department of Transportation (WisDOT), he attempted to compile a useful and manageable survey sample by locating regional concentrations of truss bridges subject to replacement pressures. Danko's second volume reported his methodology and the results of his field reviews. Intensive survey forms were included for 35 bridges.

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[3] Dan Grove Deibler, A Survey and Photographic Inventory of Metal Truss Bridges in Virginia: 1865-1932, vols. 1-5 (Charlottesville, VA: Virginia Highway and Transportation Research Council, 1975-1976); P.A.C. Spero, Metal Truss Bridges in Virginia: 1865-1932, vols. 6-8 (Charlottesville, VA: Virginia Highway and Transportation Research Council, 1982). For other early, truss-bridge studies, see statewide bridge study citations in the bibliography.

[4] George M. Danko, "The Development of the Truss Bridge, 1820-1930, with a Focus Toward Wisconsin," Ms., State Historic Preservation Office, State Historical Society of Wisconsin, 1976; George M. Danko, "A Selective Survey of Metal Truss Bridges in Wisconsin," Ms., Historic Preservation Division, State Historical Society of Wisconsin, 1977.

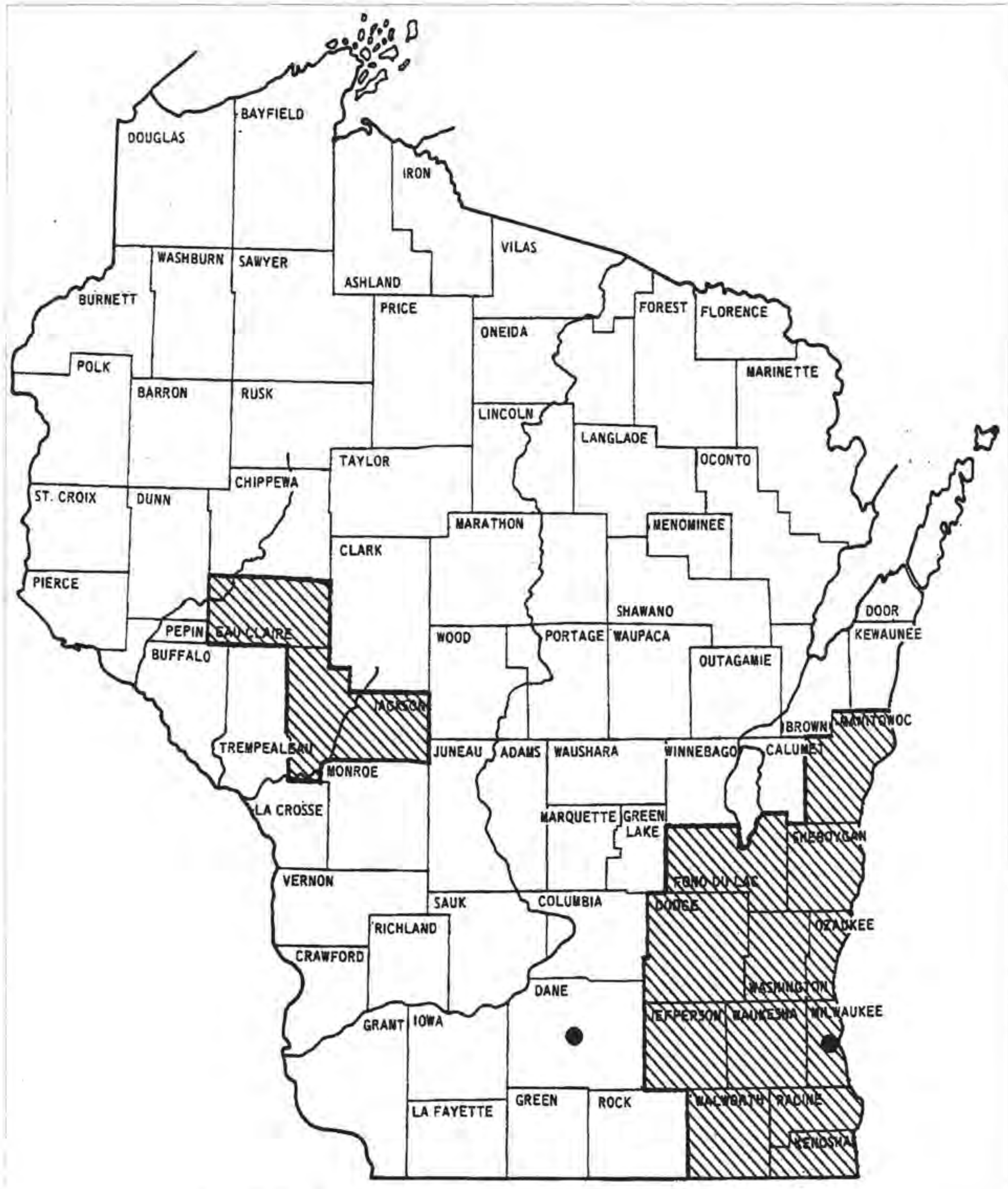

Figure 1: Counties included in Danko's 1977 field survey of truss bridges.

WisDOT took the lead in extending Danko's truss-bridge study to cover the rest of the state by adding a historian to the staff of its Environmental Bureau and establishing the Historic Bridge Advisory Committee (HBAC). HBAC consisted of members from WisDOT's Environmental Bureau, Design Section, and Bridge Section, as well as representatives from SHPO, the Federal Highway Administration (FHWA), and the University of Wisconsin–Madison, College of Engineering. HBAC members were informed that "the purpose of the historical bridge study is twofold: to meet the requirements of federal historic preservation legislation and to preserve a significant element of Wisconsin's history."[5]

Danko had recommended that 13 bridges from his study be considered eligible for the National Register.[6] Although a thematic determination of eligibility for these bridges was never completed, two were subsequently determined individually eligible. By 1980, the number of eligible bridges recognized in the state, most of them trusses, was 17 (see Table 1). None of these evaluations, however, had benefitted from a fully developed, statewide, historical context. Danko's studies did not provide specific criteria for rating truss bridges. Moreover, outside the counties that Danko had surveyed, truss bridges of obvious significance were being "discovered" and proposed for replacement. Inevitably, some of these bridges became entangled in a lengthy review process.

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[5] "Concepts of Historical Bridge Survey," unpublished memo prepared for HBAC, May 1981, in WisDOT Staff Historian's files.

[6] Danko made his recommendations concerning National Register eligibility on the original survey forms he supplied to SHPO. These recommendations do not appear on the survey forms reproduced in his "Selective Survey," nor does Danko discuss the matter elsewhere in his report.

TABLE 1
National Register Bridges in Wisconsin
(identified in 1980)
(N=17)

Name	Type	County	Date
Cedarburg Covered Bridge	Town Lattice Truss	Ozaukee	1876*
Turtleville Iron Bridge	Pratt Through Truss	Rock	1887*
Belleville RR Bridge	Pratt Through Truss	Dane	1888‡
Sock Road Bridge	Pratt Through Truss	Dodge	1893*(Demolished 1980)
Longwood Bridge	Camelback	Clark	1894‡(Demolished 1982)
Van Loon Bridge Group	Metal bowstring (5)	La Crosse	1891-92*
	Wood King post (1)		1920 (Demolished, 1986)
Shioc River Bridge	Stone Arch	Outagamie	1906‡
Soo Line High Bridge	Steel-Arch Viaduct	St. Croix	1911*
Rice Avenue Bridge	Steel Spandrel Arch	Bayfield	1912†
Hemlock Bridge	Pennsylvania Truss	Clark	1915‡(Demolished 1982)
Leedle Mills Bridge	Pratt Through Truss	Rock	1916†
Black River Bridge	Pennsylvania Truss	Jackson	1922‡(Demolished 1986)

* *Individually listed on National Register.*
† *Listed as part of Historic District or Multiple Resource.*
‡ *Officially declared eligible, but not listed.*

The goal for HBAC, then, was a statewide inventory that would expedite the evaluation of truss bridges, which, in 1980, accounted for approximately one-tenth of the states's 10,386 surviving highway bridges built before 1950. A thematic determination of eligibility was planned for those truss bridges chosen as significant in their own right or as representative of a particular truss type. In compiling an authoritative list of all eligible truss bridges, HBAC hoped to reduce conflicts while laying the groundwork for the development of a comprehensive preservation plan that would eventually include all other types of bridges as well.

Guided by the basic assumption that all distinctive types of truss bridges are worthy of some degree of preservation, planning for the statewide survey focused on two major information sources in the WisDOT Bridge Section: (1) a card file containing rudimentary structural information and a photograph for every highway bridge in the state; (2) a computerized data bank adapted to meet the FHWA's interest in a statewide inventory to determine sufficiency ratings.[7] These information sources generated an initial pool of 996 pre-1941 truss bridges representing 18 structural types (see Table 2).[8] The 1941 cutoff date was selected to satisfy, with a comfortable margin, the 50-year age criterion customarily required for National Register eligibility; the date also was considered appropriate because World War II, for all practical purposes, marked the end of metal truss-bridge construction in Wisconsin.[9]

On the basis of data derived primarily from WisDOT sources, the initial pool was carefully studied to identify, for each truss type, those bridges with the earliest known construction dates, the most intact condition, available historical data (e.g., bridge plates, SHPO research dossiers, previous historical studies), and noteworthy technological features (e.g, longest span, greatest number of spans, unusual workmanship). This winnowing reduced the initial pool by approximately 75 percent. Up to this point, the study had focused exclusively on bridges on or over public thoroughfares, including city streets, county highways, and town roads. Some bridges of historical interest, however, were known to exist in park settings and were also included in the study. With these additions, the study sample totaled 247 potentially eligible bridges.

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[7] The sufficiency rating is a numerical score based on a formula for structural design and condition, serviceability, functional obsolescence, and essentiality for public use.

[8] Originally, Pratt pony trusses with a single vertical were considered to be a separate category, but this distinction was subsequently dropped and the number of categories reduced to 17.

[9] See Danko, "Selective Survey" 1.

TABLE 2
Summary of Pre-1941 Wisconsin Truss Bridges
(identified in 1983)

Type (N=18)	Total Evaluation (N=996)	Potentially Eligible Sample (N=247)	Potentially Eligible (N=53)
PONY TRUSSES			
Bedstead (Truss Leg)	8	8	2
Bowstring	1	1	0
Howe	2	2	2
King Post	3	3	3
Parker	1	1	1
Pratt, full-slope	69	25	5
Pratt, half-hip	125	22	5
Pratt, single-vertical	5	4	0*
Queen Post	1	1	1
Warren, standard	443	23	3
Warren, continuous top chord	42	36	2
Warren, double-intersection, inclined endpost	5	5	1
Warren, double-intersection, square endpost	7	7	1
OVERHEAD TRUSSES			
Camelback	5	4	3
Parker	36	14	3
Pennsylvania	5	5	2
Pratt Pre-1890	5	5	4
1890-1910	32	23	7
1911-1925	49	13	1
1926-1931	20	7	1
1932-1936	17	6	2
Warren	35	10	2
DECK TRUSSES\All types	80	22	2

** Determined not to be a category and dropped from consideration.*

To determine the most significant bridges within each truss category, a set of evaluation criteria, with a corresponding numerical rating system, was based on the Virginia model. A trial run was conducted on the bedstead-truss (truss-leg) category. Because this category consisted of only eight examples, it was possible to rate all of them and compare the results with a "subjective" analysis of the group. The criteria were revised in light of this experience and then applied to each category with more than a dozen examples (see Table 3). Evaluations included a field review of the structure, and, when time permitted, limited historical research.

The HBAC evaluation process yielded a final group of 53 truss bridges deemed potentially eligible for the National Register. A thematic determination of eligibility, however, was not completed, and some attrition occurred. In 1986, WisDOT reevaluated the remaining truss bridges, selected "next-best" substitutes for those that had been replaced, and initiated an intensive survey to document authoritatively the National Register eligibility of the sample. The field survey was conducted, on a contract basis, by historians Jeffrey A. Hess and Robert M. Frame III. The intensive survey sample contained a total of 55 truss bridges, including two National Register bridges (P-18-720, Old Wells Bridge, Eau Claire, Eau Claire County and P-53-162, Turtleville Iron Bridge, town of Turtle, Rock County) and one bridge not located on the state highway system (the Allenton Park Bridge in the Town of Addison, Washington County) for which additional information was desired.[10] In addition to an in-depth field inspection, the consultants compiled historical research dossiers on the bridges from local and state archives, libraries, and oral informants.

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[10] WisDOT assigns a three-part designation to each highway bridge consisting of a letter ("B" for state-owned bridges; and "P" for county- and town-owned bridges), a county code number, and an individual bridge number.

TABLE 3
Historic Bridge Advisory Committee Criteria For Evaluating Significance

	Points	Total
A. Technology		
1. Span length	10	
2. Number of spans	10	
3. Distinctive Features	10	
Total Possible Points		30
B. Integrity		
1. Top and bottom chords	6	
2. Intermediate posts	6	
3. Bracing (diagonals, counters, top and bottom laterals, ties, struts, etc.)	6	
4. Abutments	2	
Total Possible Points		20
C. Condition		
1. Top and bottom chords	6	
2. Intermediate posts	6	
3. Bracing	6	
4. Abutments	2	
Total Possible Points		20
D. Documentation		
1. Date	5	
2. Manufacturer		
a. Known, unusual designer, or prolific builder	10	
b. Known, local builder	6	
c. Known, contribution unknown	3	
Total Possible Points		15
E. Context		
1. History	7	
2. Integrity of Location	4	
3. Aesthetics	4	
Total Possible Points		15
TOTAL POSSIBLE SCORE		100

The results of the 1986 intensive survey indicated that 48 bridges were immediately eligible for the National Register and that two would be eligible when they became 50 years of age (P-09-715, Central Street Bridge, Chippewa Falls, Chippewa County; and P-10-266, Lynch Bridge, town of Levis, Clark County).[11] These 50 bridges represented 33 Wisconsin counties. It was also determined that three bridges in the sample were ineligible for the National Register. Two bridges (P-04-043 and P-04-044, Lakeview Road Bridges in the town of Port Wing, Bayfield County) were ineligible primarily because of their surprisingly recent construction dates.[12] The Mulberry Lane Bridge (P-60-117) in the town of Medford, Taylor County was found to be ineligible because of its poor condition.[13] Intensive Survey Forms for each bridge are included in *Part 2: Appendix* of this study.

[11] The Lynch Bridge (P-10-266) was replaced in 1992.

[12] The Lakeview Road Bridge (P-04-044) was replaced in 1992.

[13] The Mulberry Lane Bridge (P-60-117) was replaced in 1989.

CHAPTER 2

THE METAL-TRUSS BRIDGE

Origins

Most authors begin their story of truss-bridge development in the United States with the efforts of the Massachusetts engineer Timothy Palmer in the 1790s. Strictly speaking, Palmer's most lauded designs were not true trusses, but combined the attributes of arch and truss. This hybrid type continued into the early 1800s, especially in the work of Lewis Wernwag and Theodore Burr.[14] Constructed entirely of wood, these early American spans generally were covered by a roof as protection against decay.[15]

Although iron began to replace some of the wood structural members in American bridges during the mid-nineteenth century, wood was still the most abundant and familiar construction material in many regions. Accordingly, "the general use of timber trusses for highway bridges continued to the 1880s." Gradually, iron, and later, steel, overcame initial prejudices and deficiencies, so that by the end of the century, "the most common bridge built...was the metal truss bridge." Dozens of designs were patented, but only a few became popular.[16]

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[14] J. B. Johnson et al., The Theory and Practice of Modern, Framed Structures, 8th ed. (New York: J. Wiley & Sons, Inc., 1905), 5; Henry G. Tyrrell, History of Bridge Engineering, (Chicago: published by the author, 1911), 126-130; J.A.L. Waddell, Bridge Engineering, vol. 1 (1916 Reprint; New York: J. Wiley & Sons, 1925), 19-20; H.J. Hopkins, A Span of Bridges (New York: Praeger, 1970), 116-117; George M. Danko, "Evolution of the Simple Truss Bridge, 1790 to 1850: From Empiricism to Scientific Construction," PhD. diss., U of Pennsylvania, 1979, 34-67.

[15] Wisconsin's only surviving covered wood bridge is a Town Lattice truss in the City of Cedarburg, Ozaukee County. See Donald N. Anderson, "National Register Nomination for the Cedarburg Covered Bridge," Ms., State Historical Society of Wisconsin-Historic Preservation Division, 1972.

[16] Ellis Armstrong, ed., History of Public Works in the United States, 1776-1976 (Chicago: American Public Works Association, 1976), 109. Comp and Jackson put the period of metal truss dominance at 1850 to 1925, but these dates are possibly too generous, even for states east of Wisconsin; see T. Allan Comp and Donald Jackson, "Bridge Truss Types: A Guide to Dating and Identifying." American Association for State and Local History, Technical Leaflet 95, History News, 32 (May 1977). For dissenting views, see George S. Morrison et al., "American Engineering as Illustrated by this Society at the Paris Exposition of 1878," Transactions of American Society of Civil (continued...)

On Wisconsin highways, the predominance of metal-truss bridges for crossings of all lengths seems to have lasted from about 1890 to 1910. After 1910, most new construction for short crossings employed girder, beam, or slab spans of steel and/or concrete. The Wisconsin SHC, established in 1911 to improve the quality of road and bridge construction in the state, was particularly enthusiastic about using concrete for culverts and small bridges. At the same time, however, the SHC continued to advocate the use of metal trusses for most spans over 35 feet in length.[17] Until the advent of World War II, the metal truss remained an important bridge type in Wisconsin. Noteworthy examples of late metal-truss construction are the Central Street Bridge (P-09-715), completed in Chippewa Falls in 1939, and the Lynch Bridge (P-10-266), erected in the town of Levis, Clark County, in 1940.[18]

Definitions

There are numerous definitions of a truss (see generalized diagram in Figure 2), but each focuses on three essential aspects. First, a truss is a combination of relatively small members that are "framed or jointed...to act as a beam."[19] Second, each component member is subjected only to tension or compression. (Tensile forces tend to stretch or elongate a member, while compressive forces tend to push or compress a member.) Third, the component members are configured in triangles because "the triangle is the only geometric figure in which the form is changed only by changing the lengths

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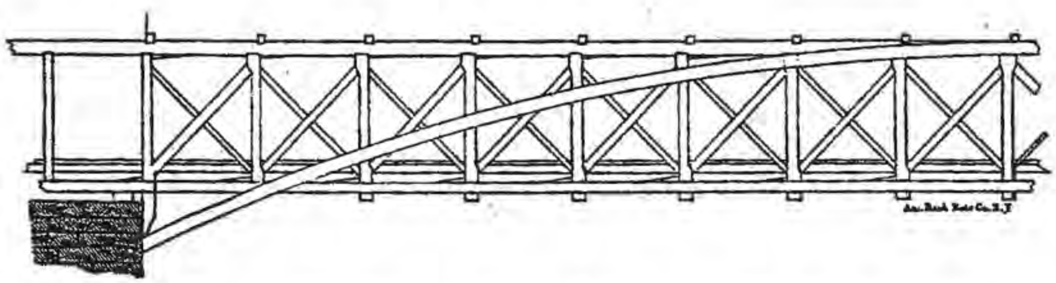
[16](...continued)
Engineers 7 (Nov.-Dec. 1878): 343; Milo S. Ketchum, The Design of Highway Bridges (New York: The Engineering News Publishing Co., 1908), 399-402; F.B. Brock, "An Illustrated Historical Description of All Expired Patents on Truss Bridges," Engineering News and American Contract Journal 9 (1882): 371-72 and 10 (1883): 421-22.

[17] Wisconsin State Highway Commission, Second Biennial Report...1911-1915 (Madison, Wis.: published by the State, 1915), 24, Plates VI, VII, VIII; M.G. Davis, A History of Wisconsin Highway Development, 1835-1945 (Madison, Wis.: Wisconsin Department of Transportation, 1947), 104-105.

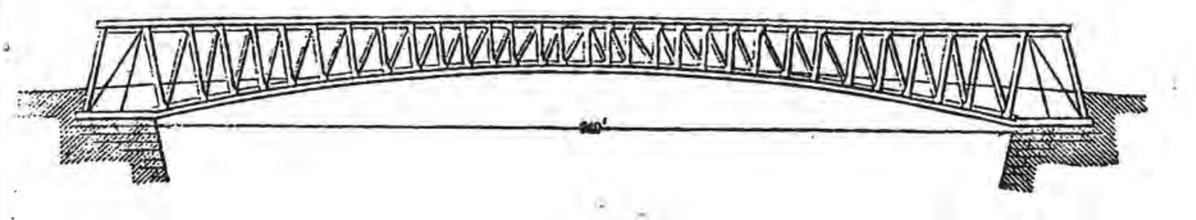
[18] The Lynch Bridge (P-10-266) was replaced in 1992.

[19] Johnson et al., The Theory and Practice of Modern Framed Structures, 3; In other words, the "assemblage had rigidity and behaved as a unit"; Armstrong, 109.

A. Timothy Palmer's "Permanent Bridge" over the Schuylkill River, Philadelphia. Built in 1804, the bridge had a middle span of 195 feet, and side spans of 150 feet each.



B. Part of Span No. 3, Theodore Burr's bridge over the Hudson River, Waterford. Span lengths were 154 feet, 161 feet, 176 feet, and 180 feet.



C. Lewis Wernwag's Colossus Bridge over the Schuylkill River, Philadelphia. Built in 1812, it had a single span of 340 feet.

Figure 2: Early trussed arches. (Source: J.B. Johnson, C.W. Bryan, and F.E. Turneaure, The Theory and Practice of Modern Framed Structures 8th ed., [New York: J. Wiley & Sons, Inc., 1905], 67).

of the sides."[20] In other words, the triangle remains rigid until the forces applied distort or break the members.

As a result of its clear-cut geometry, the truss configuration both encouraged and simplified the use of scientific formulas for bridge design. The total load that a bridge needed to carry—called the "live load"—had always been relatively easy for engineers to calculate or assume. With a truss bridge, it also became much simpler to calculate the forces to which the various components would be subjected, allowing the determination of their proper thickness.[21] Scientific proportioning of the members meant that truss bridges could be designed to carry the maximum live load, while keeping the weight of the bridge itself—the "dead load"—to a minimum. Lighter bridges were not only more efficient, they were also cheaper. And because they had less dead load, they could carry a larger live load over a longer span. Because of its special attributes, the truss bridge appears to have been an important agent in furthering experimentation and analysis in materials, design, and construction.[22]

Truss bridges are generally divided into three categories: (1) pony, or low, trusses; (2) overhead, or through, trusses; and (3) deck trusses.[23] In both pony and overhead trusses, the roadway is located at or near the level of the bottom chord, so that traffic travels between the sides of the structure. (For a typical pony truss, see Figure 3; for typical overhead truss, see Figure 4). In a deck truss, the roadway is located at or near the level of the top chord, so that traffic travels along the top of the structure. The component members of the truss extend below the roadway, requiring sites with

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[20] Ketchum, 1.

[21] See example, Squire Whipple, An Elementary and Practical Treatise on Bridge Building (New York: D. Van Nostrad, 1873), 5-7; William E. Merrill, Iron Truss Bridges for Railroads 2nd ed. (New York: D. Van Nostrad, 1870), 11-24.

[22] See Danko, "Evolution of the Simple Truss Bridge," Chapter 3, for a discussion of the interaction of changes in college education, influence of European textbooks, and the impact of the railroad.

[23] Comp and Jackson, 5-7; Ketchum, 5-11. One also sees reference to overhead trusses as "high" trusses.

Figure 3: A typical highway, pony truss: Sprague Bridge (P-29-092) in the Towns of Armenia and Necedah, Juneau County; built in 1913 by Elkhart Bridge and Iron Company. (Source: W.E. Gifford, Sr.).

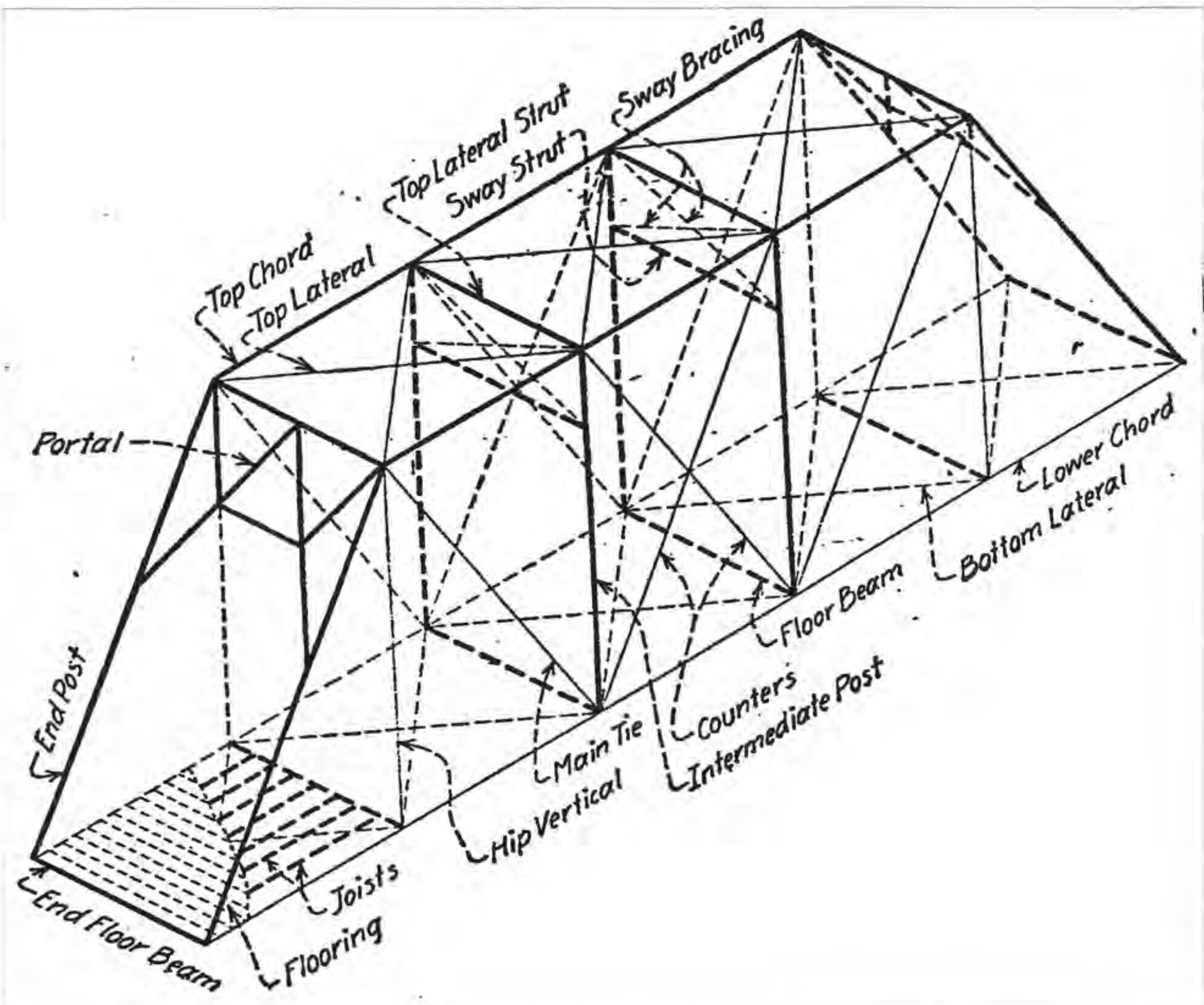

Figure 4: Diagrammatic sketch of an overhead Pratt truss highway bridge. (Source: Milo S. Ketchum, The Design of Highway Bridges [New York, 1908], p. 2).

considerable vertical clearance. Since Wisconsin has few deep gorges, deck trusses have always been relatively rare (see Figure 5).[24]

Materials

Iron and steel, the structural building materials of the late nineteenth and early twentieth centuries, were by no means discovered during that period. Iron technology began in prehistoric times, and steel had been known for centuries. However, the understanding of iron and steel's chemical and physical properties was not sufficiently advanced to see the widespread application of these materials until well into the nineteenth century. Final acceptance of these metals also required dramatic changes in the manufacturing process. Eventually, increased reliability, uniformity, and availability of iron and steel combined with decreased cost to facilitate their extensive use.[25]

At the beginning of the nineteenth century, engineers had at their disposal two main types of iron: cast iron and wrought iron. Manufactured by a centuries-old process, cast iron was cheaply produced and easily poured into structural shapes, making it the initial metal of choice for bridge construction. Wrought iron, in contrast, was worked with far more difficulty, and had only recently entered the domain of mass production with the development in England of the "puddling" process.[26] By mid-century, English investigators had scientifically established that the two types of iron had quite

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[24] A more recent trend is the construction of welded, Warren, deck trusses with heavy members and relatively shallow trusses.

[25] On iron and steel technology, see James Aston and Edward B. Story, Wrought Iron 11th ed. (Pittsburgh: A.M. Byers, 1939), 3-15; see also, Mansfield Merriman, Mechanics of Materials (New York: J. Wiley & Sons, Inc., 1914), 57. On early iron manufacturing in the United States, see John Fritz, "The Development of Iron Manufacture in the United States," Cassiers Magazine 17 (March 1900): 459-471; Walter K.V. Gale, Iron and Steel (London: Longmans, 1969): 73-79; Douglas A. Fisher, The Epic of Steel (New York: Harper & Row, 1963), 126-127. On early precedents, see Fisher, 103 and 163; David Plowden, Bridges: The Spans of North America (New York and London: W.W. Norton & Co., 1974), 125.

[26] For a brief description of wrought-iron manufacture, see George Schuhmann, "Iron and Steel", The Pilot (April 1906), reprinted in "Data Sheet No. 4"; Society for Industrial Archeology spec. issue, October 1984.

Figure 5: A rare Wisconsin deck truss: Ishnala Road Bridge (P-56-702), Mirror Lake, Sauk County; built in 1908 by Wisconsin Bridge and Iron Company; replaced in 1986. (Source: WisDOT).

different physical properties. Cast iron was the stronger of the two under compressive forces, but its brittleness made it subject to dramatic failure under tensile forces. Wrought iron, on the other hand, was capable of withstanding both types of forces, although it was stronger in tension. As historian Carl W. Condit has pointed out, American builders initially showed little interest in these findings, "with the result that failures of early iron bridges and building frames occurred with discouraging frequency."[27] Through the 1830s, American truss bridges were made entirely of wood, even using wood "tree nails," or pins, for the connections (see Figure 6).[28] When iron was introduced into American bridge design, it was not as a new material with special properties to be exploited in their own right, but rather as a substitute material that could solve some of the deficiencies of wood, namely fire, decay, and decreasing quality.[29]

In 1840, Massachusetts engineer William Howe patented a truss that used wrought-iron rods for the tension members, while retaining wood beams for the compression members (see Figure 7). Four years later, Thomas and Caleb Pratt, sons of a Boston architect, patented a similar truss, but with the wood compression beams vertical rather than diagonal. Also in the 1840s, a number of American builders and inventors experimented with the concept of an all-iron truss bridge. The first successful and influential examples were constructed by Squire Whipple, who used two basic types: a "bowstring" (or arch) and a Pratt. Both of Whipple's designs featured cast iron in compression and wrought iron in tension. Other metal trusses were developed by such prominent engineers as Benjamin Latrobe, Albert Fink, and Wendel Bollman.[30] Although no examples of the distinctive Fink and

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[27] Carl W. Condit, American Building, 2nd ed. (Chicago: U of Chicago Press, 1968), 78-79.

[28] Treenails are also known as "trenails" and "trunnels," presumably verbal corruptions of "tree nail."

[29] Tyrrell, 151-154; Theodore Cooper, "American Railroad Bridges," Transactions of the American Society of Civil Engineers 8 (October 1879): 11-18.

[30] Condit, 93-102.

Figure 6: The tree nails are the small circular objects at the intesection of the lattice work; Cedarburg Covered Bridge, Ozaukee County; built in 1876; now closed to vehicular traffic. (Source: WisDOT).

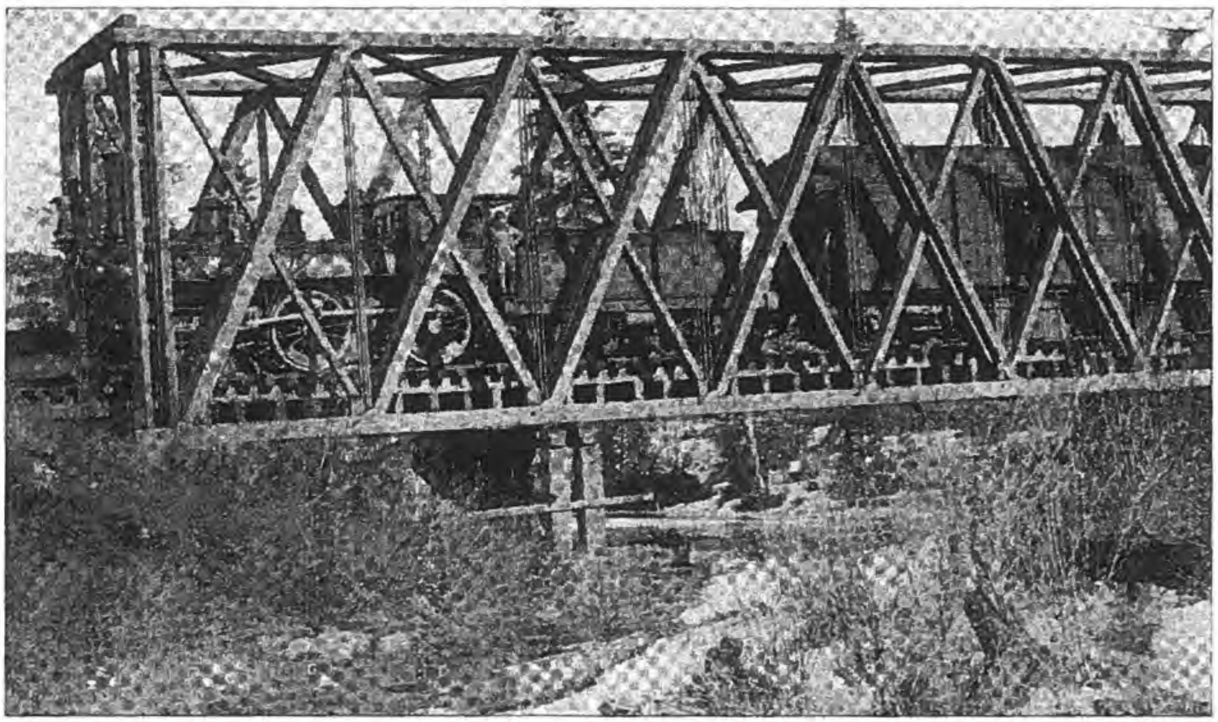

Figure 7: Howe truss over White River on the Wisconsin Central Railway, c. 1875. (Source: Roy L. Martin, History of the Wisconsin Central [Boston: Railway and Locomotive Historical Society, 1941]).

Bollman trusses are known to survive in Wisconsin, there were two Fink deck trusses on the Wisconsin Central Railway in the 1890s.[31]

The American debate over the comparative safety and utility of cast iron and wrought iron continued into the 1870s, with some engineers insisting that "the rigidity of cast-iron is the very quality needed in a compression member."[32] The issue was never entirely resolved. Instead, it was replaced by controversy over a new material in bridge construction—steel. Steel was "new" only in the sense that its high production cost and the resultant small output had previously restricted its use. After the Civil War, the Bessemer and Open Hearth processes significantly reduced the price of steel production, subsequently increasing the quantity of structural steel and enabling those engineers who appreciated its great strength to consider its adoption. Steel made its debut in bridge construction in 1874 in the Eads Bridge in St. Louis. By 1890, major manufacturers of structural shapes were rolling beams and columns in both wrought iron and steel.[33]

It has been suggested that the term "steel" was applied to a variety of materials simply because there was "marketing value" to the name, and that from the viewpoint of historic preservation in Wisconsin, the distinction between steel, cast iron, and wrought iron in truss bridges is not a useful one.[34] There is something to be said for this position. For one thing, the materials are difficult to distinguish in the field. For another, there are no obvious, significant differences in truss design that

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[31] Lura J. Turner, Handbook of Wisconsin: Its History and Geography (Burlington, Wis.: L.J. & J.M. Turner, 1898).

[32] Theodore Cooper, "The Use of Steel for Bridges," American Society of Civil Engineers, Transactions 8 (October 1879): 265.

[33] Merrill, 126; Plowden, 125-127; Fisher, 103 and 117; Herbert W. Ferris, ed., Historical Record, Dimensions and Properties: Rolled Shapes, Steel and Wrought Iron Beams and Columns (New York: American Institute of Steel Construction, 1953).

[34] Barbara Wyatt, ed., Cultural Resource Management in Wisconsin (Madison, Wisc: State Historical Society of Wisconsin, 1986), Section 12-2: "Iron and Steel Truss Highway Bridges." For discussion also see J.B. Johnson et al., Johnson's Materials of Construction, 7th ed. (New York: J. Wiley & Sons, Inc., 1930).

accompanied the change in materials (see Figure 8). Some bridges constructed in the state in the 1890s probably contained both metals. In the final analysis, however, there are only a dozen or so truss bridges in Wisconsin old enough to be made exclusively of wrought iron.

Nevertheless, there was genuine disagreement among prominent bridge engineers of the time about the nature of the three metals and their suitability for bridge construction. Admittedly, steel suffered from a lack of "homogenous quality," and as late as 1906, there was uncertainty and ambiguity about the chemical and physical properties of the multitude of mixtures covered by the word "steel."[35] This is a different issue, however, than the distinction between iron and steel, and the perception of that difference by engineers at the time. To ignore this distinction then, is to ignore the complex story of the introduction of steel in bridge building.

In 1879, Theodore Cooper, a leading bridge engineer, wrote that "the substitution of steel for iron for bridges has become a prominent feature of discussion among engineers and bridge builders." Although Cooper noted that some engineers remained skeptical about the use of steel, he himself had little doubt of its eventual acceptance: "Steel must enter upon a struggle for precedence with iron, somewhat similar to that which iron has been undergoing, with reference to wood for the past forty years, and will undoubtedly come out in the end as victorious."[36] Nevertheless, Cooper was not ready to recommend steel's unqualified or untutored use.

The first step in steel's "struggle for precedence" was for engineers to define those physical properties they required in the metal. Acknowledging that the term "steel" was applied to a variety of products, Cooper advised his colleagues to leave chemical investigations and improvements to the chemist and the manufacturer. The engineer's job was to specify appropriate tensile strength and

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[35] "The Use of Steel in Bridge Construction," Engineering Record 25 (27 February 1892): 210. For a discussion of the variations in elasticity of both iron and steel, see T. Claxton Fidler, A Practical Treatise on Bridge-Construction: Being a Text-Book on the Design and Construction of Bridges in Iron and Steel (London: C. Griffin & Co. ltd., 1887), 167-170.

[36] Cooper, "The Use of Steel for Bridges," 263.

Figure 8: This wrought iron, overhead, Pratt truss was built in downtown Burlington in 1877 by the Milwaukee Bridge and Iron Company. It was moved to its current location on the edge of town over the White River in 1920. It is privately owned. (Source: HAER No. WI-16).

ductility, establishing standards compatible not only with the material's ultimate use but with all aspects of its manufacture—rolling, bending, cutting, punching, drilling, and finishing.[37]

It is hard to say how well the engineering profession heeded Cooper's advice, but his colleagues did continue to debate the quality of various types of steel. In 1895, for example, H.H. Campbell concluded that acid open-hearth nickel steel, despite what was "commonly supposed," did not show a marked superiority to carbon steel of similar tensile strength. A year later, Henry Wiggin came to the opposite conclusion.[38] In 1900, an article in Engineering Record—appropriately titled "Unsettled Questions Concerning Steel for Important Bridges"—noted that differences of opinion over specifications for bridge steel "has at times manifested itself in open controversy and litigation."[39]

The second step in steel's acceptance was for the manufacturing process to provide appropriate quantities of a low-cost, reliable product. To complete this step, the industry needed to produce both a reliable material and usable shapes. At the time of Cooper's comments, the Bessemer and Open Hearth methods both had the potential to provide good quality raw steel. But according to the noted bridge engineer, J.A.L. Waddell, Bessemer steel suffered from a poor reputation for quality control and was never popular for bridge work. Apparently, after the turn of the century, Bessemer steel was used mainly for railroad rails, while Open Hearth steel was used for structural purposes, as well as for machines, shafts, and other components.[40]

Another element required in the manufacturing step was reliable shapes that best used the basic strength of the material. In 1896, the Association of American Steel Manufacturers facilitated

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[37] Cooper, "The Use of Steel for Bridges," 266-267.

[38] H.H. Campbell, "The Physical Qualities of Acid Open-Hearth Nickel Steel, as Compared with Carbon Steel of Similar Tensile Strength," Transactions of the American Society of Civil Engineers 34 (Oct. 1895): 288; Henry Arthur Wiggin, "Nickel Steel, and its Advantages over Ordinary Steel," Industries and Iron 21 Feb. 1896: 142-143.

[39] "Unsettled Questions Concerning Steel for Important Bridges," Engineering Record 42.14 (1900): 329-330.

[40] Waddell, Bridge Engineering, 17; Merriman, 60-61. The third major method of steel manufacture—the "crucible process"—was used mainly for producing steel for tools; see Ferris, 1.

this process by adopting a classification scheme for American Standard Beams. In at least one case, however, the manufacturing process itself required fundamental revision before a component could be standardized. By the 1870s, the adjustable iron rods previously used with combination bridges had been replaced on all-metal bridges by loop-welded eye-bars (see Figure 9). But none of the initial methods of making flat steel eye-bars was entirely successful. Attempts at hammer forging, hydraulic upsetting, and welding failed to produce a uniformly reliable steel eye-bar. As one engineer observed in 1879, "it has been due to this fact, perhaps more than any other, that the value of [steel], manifestly so much better suited for structural purposes than iron, has not yet been fully recognized in bridge construction."[41]

The problem was solved by a new manufacturing process patented by Andrew Kloman and first used for bridge construction in 1878. As historian George Danko explains:

> With the use of a special mill, Kloman was able to produce a bar free from the faults incurred by upsetting or welding. The important feature of his mill was that bars of any shape or length, with enlarged parts of any size at any or various points in their lengths could be rolled as simply as a straight bar."[42]

After the bars were fashioned, they were punched by a hydraulic press to create the "eye" (see Figure 10). Kloman's punched eye-bars continued in use until the twentieth century, when riveted construction eventually replaced the eye-bar with a riveted angle section (see Figure 11).

The third step necessary for the ascendance of steel was for engineers to recognize that building with steel required some adjustments in bridge design, especially in regard to "the form of members and their details." Cooper advised engineers to pay particular attention to small details such as the diameter of eyebar openings, the size and number of rivets, and the use of gusset plates. As the

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[41] Danko, "The Development of the Truss," 24; Charles MacDonald, "A Method of Rolling Steel on Iron Eye-Bars," Engineering News 24 May 1879: 164.

[42] Danko, "The Development of the Truss," 25.

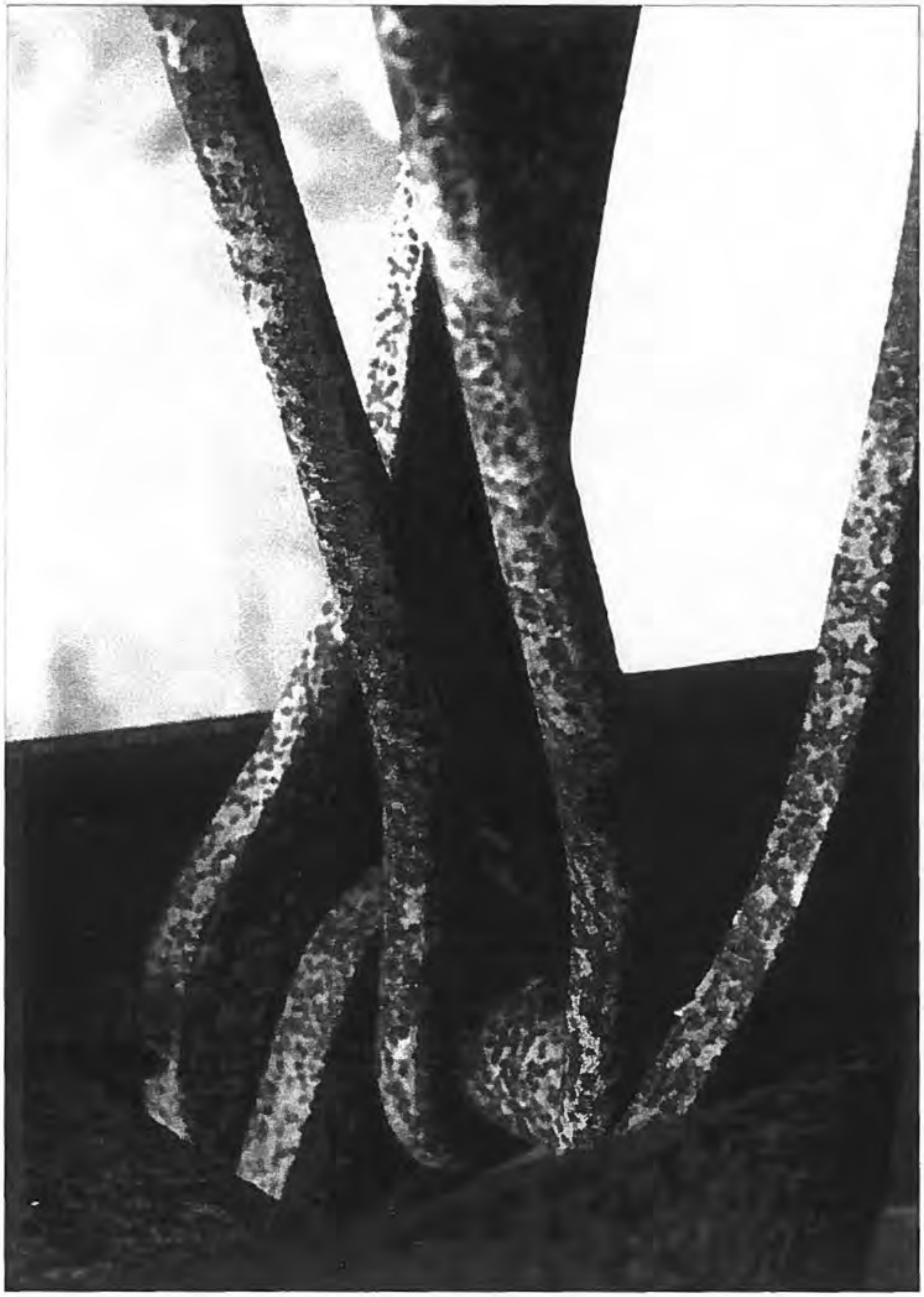

Figure 9: Loop-welded eye-bars; bottom chord of Mill Road Bridge (P-36-022), built in 1887 over Manitowoc River, Manitowoc County. (Source: WisDOT).

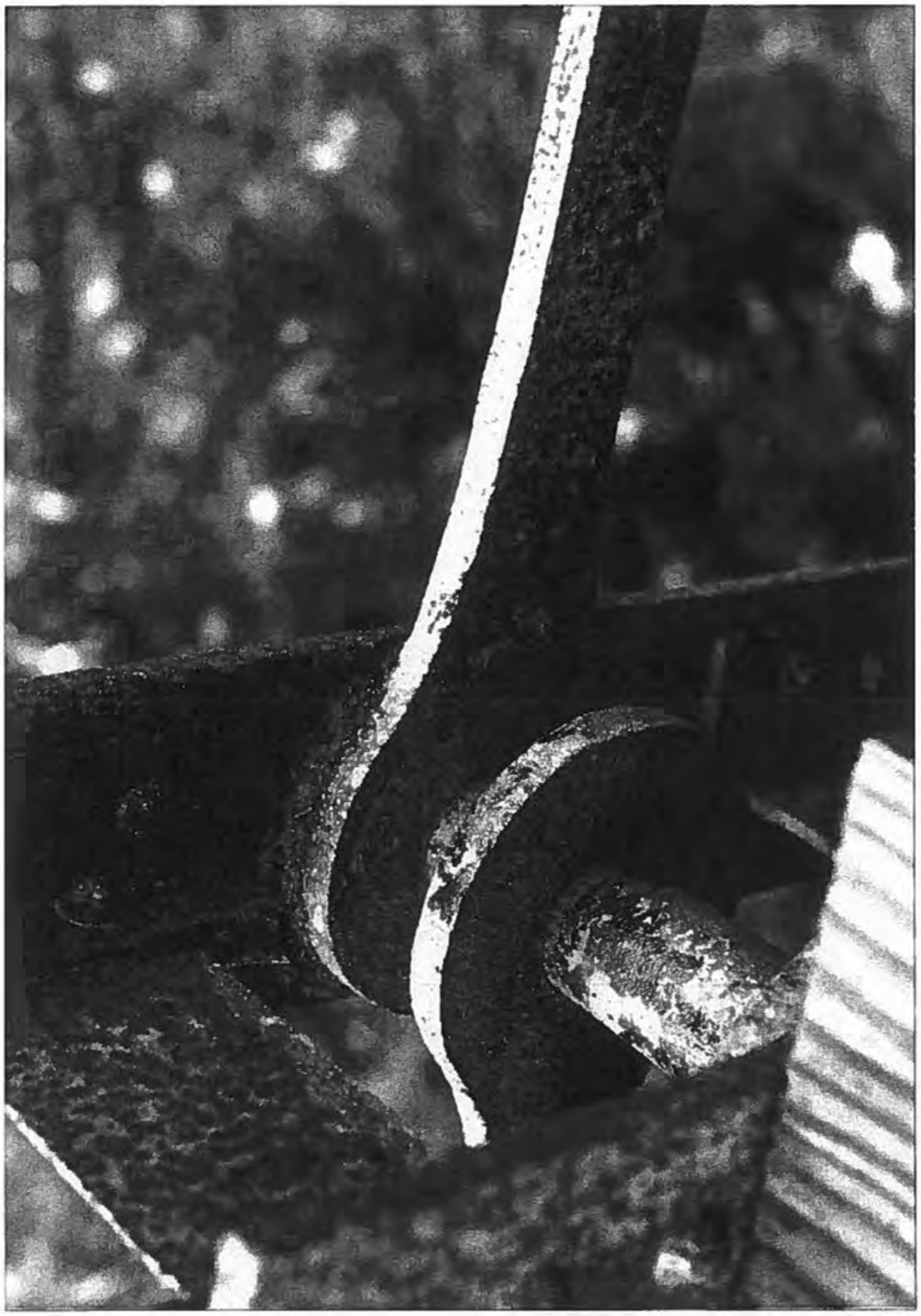

Figure 10: Kloman-type, punched eye-bars; bottom chord of Kelly Road Bridge (P-27-121), built in 1905 over Robinson Creek, Jackson County. (Source: WisDOT).

Figure 11: Riveted construction; Wagon Trail Road Bridge (B-47-006) built in 1909 over Eau Galle River, Pierce County. (Source: HAER No. WI-31).

English engineer T. Claxton Fidler pointed out, the theoretical advantage of steel over iron could be lost in practice by the waste of material in detailing.[43]

Steel's victory came as Cooper had predicted it would by experimentation to determine the material's true characteristics, by competition among manufacturers to determine its best method of production, and by increased knowledge among engineers concerning its most appropriate use.[44] There is no agreed-upon date for the change from wrought iron to steel.[45] Even after the production of wrought-iron structural shapes had largely ceased, doubters of the new material continued to raise the old objections that steel was "treacherous" and could "crack like glass."[46] Inventories of wrought iron apparently allowed bridge-building companies to advertise both metals as late as 1900.[47] But by that time, the superiority of steel over iron for structural work appears to have been generally accepted.[48]

In the twentieth century, most advances in steel technology focused on alloys. Indeed, by 1921, one English engineer concluded that the developments of the last two decades had made mild steel and wrought iron equally old fashioned. The engineer and the metallurgist alike developed an

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[43] Cooper, "The Use of Steel for Bridges," 270-272 and 275; Fidler, 327.

[44] Cooper, "The Use of Steel for Bridges," 266-267, 274-275 and 293-294.

[45] According to one author, "the eighth edition (1893) [of the Carnegie Brothers' Pocket Companion] showed steel sections only and marks approximately the end of the use of wrought-iron beams and channels"; R. Fleming "History of Structural-Steel Handbooks," Engineering News 8 Mar. 1917: 401. In Ferris, no mill is listed as producing wrought-iron shapes after 1892. Other historians have put the date of wrought iron's demise at 1895; see Tyrrell, 171; Danko, "The Development of the Truss," 20. Waddell suggests 1890 as the cut-off date; see Waddell, Bridge Engineering, 17.

[46] "A Symposium on the Use of Steel for Railway Bridges," Engineering News 25 Aug. 1892: 185; D. Torrey "Comments," in Cooper, "The Use of Steel for Bridges," 290.

[47] See advertisements for Wisconsin Bridge and Iron Company and for Wrought Iron Bridge Company in, respectively, Wisconsin State Gazetteer and Business Directory, 1895-1896 (Chicago: R.L. Polk & Co., 1895) 687 and Cassier's Magazine 17.6 (1900): 25. On the page opposite the Wrought Iron Bridge Company's announcement, the Berlin Iron Bridge Company advertised only "Steel Bridges and Buildings."

[48] In his 1906 textbook, Ketchum specifies "rolled steel" as the structural material; see Ketchum 5. F.C. Kunz, in his 1915 textbook, lists the comparative strengths of various types of steel and wrought iron, but his discussion clearly assumes steel--iron is not even listed in the index; see F.C. Kunz, Design of Steel Bridges (New York: McGraw-Hill, 1915) 433.

increasingly sophisticated understanding of the variations resulting from changes in chemical composition, heat treatment, macrostructure, and microstructure.[49] Alloy steel was to play a particularly important role in the design of very long span bridges and in the development of welded connections.[50] But these innovations belong primarily to the second half of the twentieth century, after the era of the metal-truss bridge had already come to a close.

Design and Engineering

Local histories seldom provide complete information about the precise location, date of construction, or builder of early bridges. Newspapers also seem surprisingly uninterested in reporting on the construction of even some of the larger bridges. Published county board proceedings vary greatly in the information they provide on county-funded bridge projects. However, research conducted for this study has uncovered specific information on many of Wisconsin's historic metal-truss bridges.

For early Wisconsin bridge builders, "the crib form of construction was a favorite," because it could be constructed by settlers with simple farm tools (see Figure 12). Later, the introduction of pile drivers made pile trestles more efficient in terms of labor and materials (see Figure 13).[51] Before the 1880s, most spans less than 40 feet in length were probably wood crib or trestle bridges. Indeed, a number of longer spans were also of these types. Although these simple wood bridges were cheap and easy to build, they were vulnerable to floods, even to the customary seasonal variety known as "freshets."

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[49] Leslie Aitchison, Engineering Steels (London: Macdonald, 1953), vii; see also W. E. Dalby, Strength and Structure of Steel and Other Metals (London: E. Arnold, 1923); J.A.L. Waddell, Economics of Bridgework, Chapter 5; Edwin H. Gaylord and Charles N. Gaylord, Design of Steel Structures (New York: McGraw-Hill, 1957), 43-46.

[50] On welding, see U.S. Department of Transportation, Federal Highway Administration, Design and Construction of Welded Bridge Members and Connections (Washington, D.C., 1980), 1-27.

[51] Hans Nelson Brue, "The Development of Highway Bridges in Wisconsin," thesis, U of Wisconsin, 1916, 4-5.

Figure 12: Crib bridge in Sawyer County, c. 1940; demolished. (Source: SHC files, WisDOT).

Figure 13: Trestle bridge over Namekagon River, Washburn County; demolished. (Source: WisDOT).

By the 1860s, the older forms of crib and trestle bridges were being challenged by truss configurations. During the first half of the nineteenth century, the Burr truss—a hybrid of the truss and arch forms—"stood unrivalled for cheapness and efficiency for highway purposes in this country."[52] It is not known, however, if any Burr trusses were built in Wisconsin. The state's earliest wood trusses may have been Town Lattice trusses (see Figure 14). Patented by Ithiel Town in 1820, this design was a simple truss "freed from a dependence on the arch." Ignored in some histories of truss development, the Town Lattice truss was a major competitor of the Burr truss.[53] Town lattice trusses were built for both railroads and highways, some reaching a span length of 220 feet. The lattice design produced no lateral pressure against the piers or abutments and provided, in effect, a redundancy of joints, which increased overall structural strength while lessening the strain on any one joint. An 1876 example of this type still exists in Cedarburg and is Wisconsin's only known covered wood truss bridge (see Figure 6).

The next popular improvement was the "combination" truss, so called because it combined iron and wood components. Patented in 1840, the Howe truss was the most common type, using diagonal wood beams in compression and vertical iron rods in tension. The Howe form was so successful that it was termed "the most perfect wooden bridge ever built; others have been designed of greater theoretical economy; but for simplicity of construction, rapidity of erection and general utility it stands without a rival."[54] As late as 1911, Tyrrell could write that "many Howe truss spans are still in use, and in regions where timber is plentiful this type is extensively used on new roads for

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[52] Johnson et al., "The Theory and Practice of Modern Framed Structures," 6.

[53] Danko, "Development of the Simple Truss," 38; Tyrrell, 137-138; F.B. Brock, "An Illustrated Historical Description of All Expired Patents on Truss Bridges," Engineering News and American Contract Journal 9 (1882): 371.

[54] Morrison et al., 340.

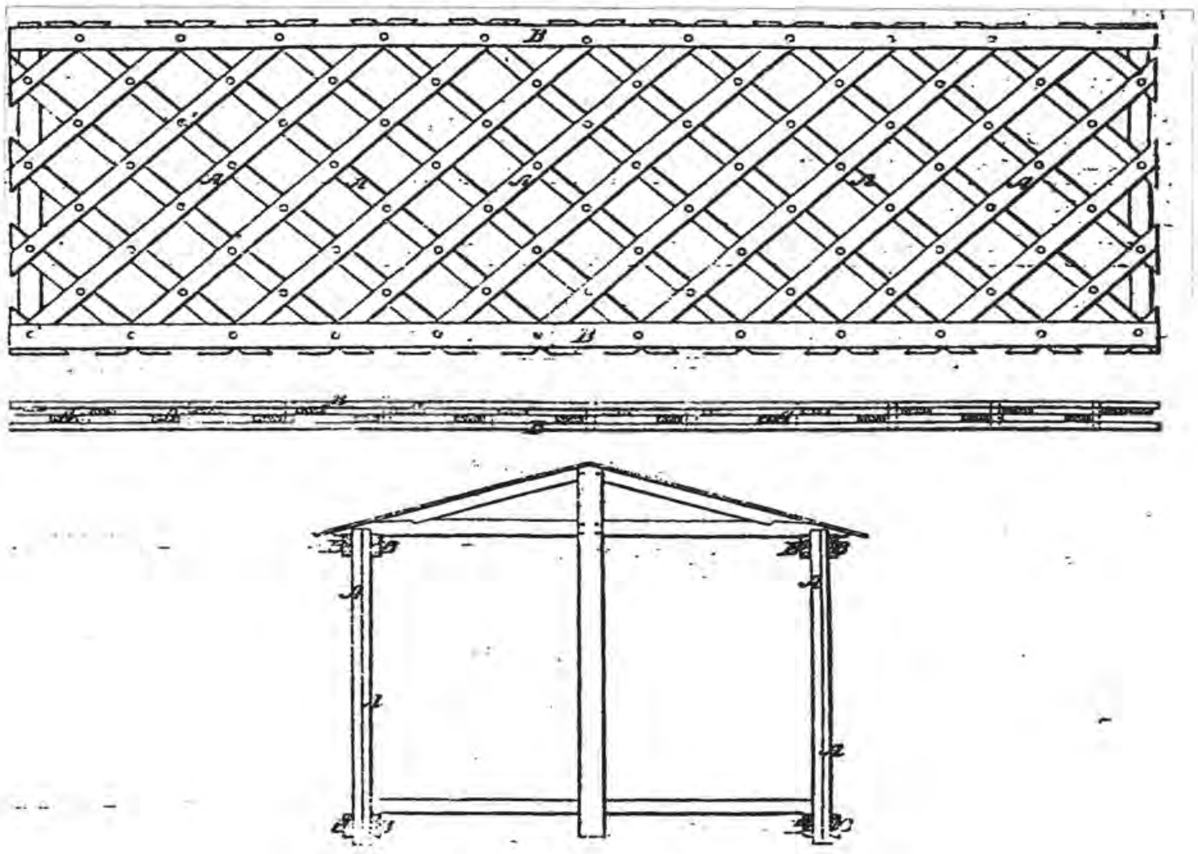

Figure 14: Town lattice truss. (Source: F.B. Brock, "Illustrated Historical Description of All Expired Patents on Truss Bridges," Engineering News and American Contract Journal, 9 (1882), 371).

temporary work."[55] The Chicago and Northwestern Railway apparently agreed with Tyrrell, as it built two Howe truss bridges in northwest Wisconsin in 1911 (see Figure 7). Both bridges were determined eligible for the National Register of Historic Places prior to their removal in the mid-1980s.[56]

The "bowstring" truss bridge may have been the state's first, common, all-metal truss configuration. Nationwide, apparently thousands were built, but the design's popularity in Wisconsin is difficult to determine.[57] Although there is little information about what once stood in the state, a bowstring built in Oconomowoc was well documented. According to municipal records, the Oconomowoc City Council in 1871—prompted by the deteriorating condition of a wood crib bridge on Main Street—traveled to Illinois to examine the recent work of several bridge companies.[58] After making their site inspections and reviewing a number of bids, the council selected an overhead bowstring design from the Wrought Iron Bridge Company of Canton, Ohio (see Figure 15). The structure was completed in 1872 and replaced at an unknown date.

No bowstrings are left on Wisconsin highways, and only eight remain in parks and wildlife preserves: five in the Van Loon Wildlife Area near La Crosse; one in Lakeside Park in Fond du Lac; and one in Tivoli Island Park in Watertown (see Figures 16, 17, and 18). Constructed in c. 1870, the Fountain Island Bridge in Lakeside Park in Fond du Lac is the oldest, existing truss bridge in Wisconsin.

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[55] Tyrrell, 142.

[56] The Seventh Street Bridge in the city of Hudson was demolished in 1987; see Robert S. Newbery and Amy A. Ross, "Seventh Street Bridge," Historic American Engineering Record Report, HAER No. WI-13, 1994.

[57] Diane Kromm, "Milford Bridge," Historic American Engineering Record Report, HAER No. WI-21, 1987.

[58] City of Oconomowoc, Clerk Records, 1871; the records of the Oconomowoc City Engineer's Office in the manuscript collection of the State Historical Society of Wisconsin, Archives Division.

Figure 15: General plan for overhead bowstring truss bridge, by Wrought Iron Bridge Company, 1870. The company built a bridge of similar design in Oconomowoc, Waukesha County, in 1872. (Source: WisDOT).

Figure 16: McGilvray Road Bowstring Truss Bridge No. 1, Van Loon Wildlife Area, La Crosse County. (Source: HAER No. WI-22, 1987).

Figure 17: Bowstring Truss Bridge, Lakeside Park, City of Fond du Lac, Fond du Lac County. (Source: WisDOT).

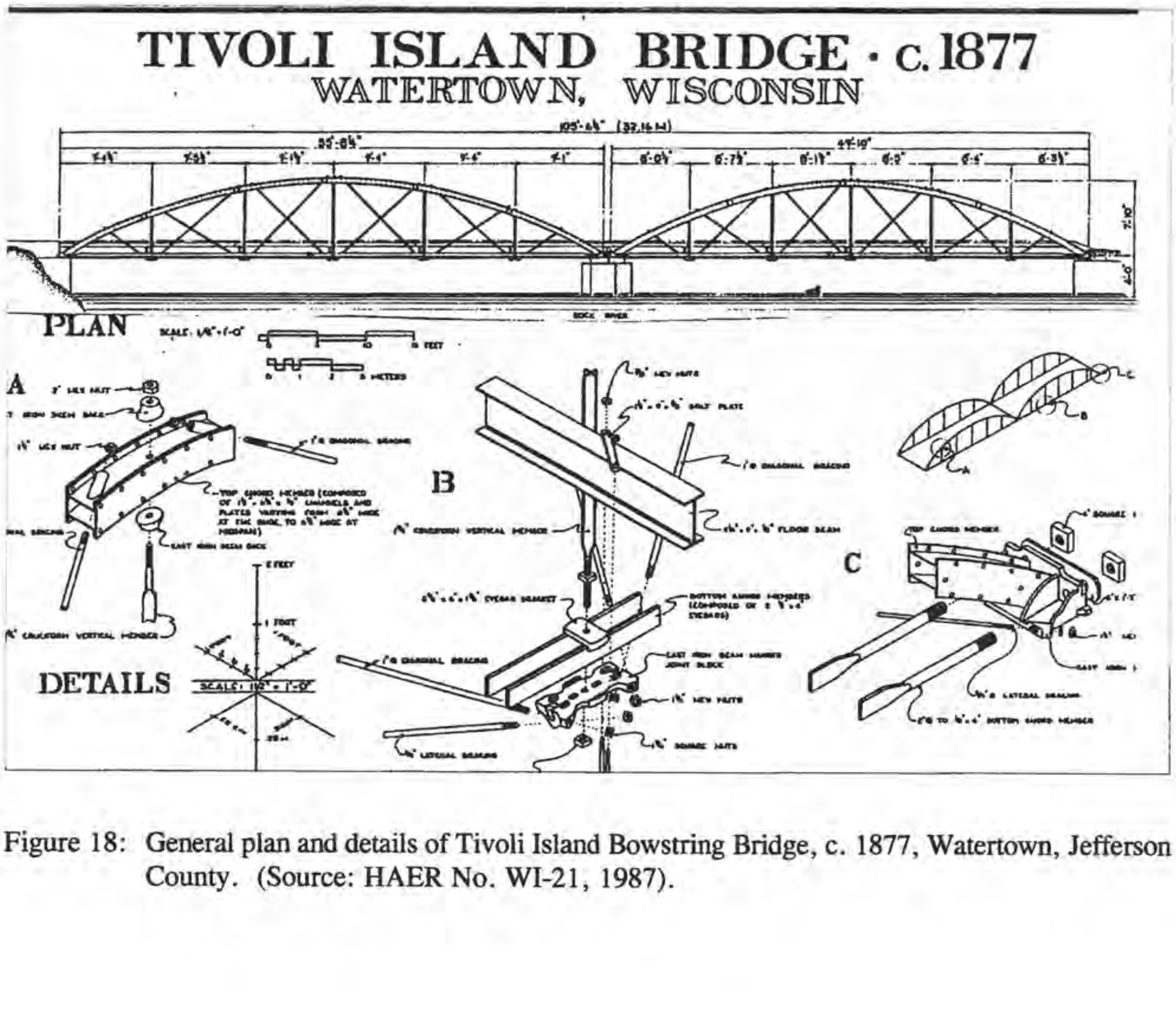

Figure 18: General plan and details of Tivoli Island Bowstring Bridge, c. 1877, Watertown, Jefferson County. (Source: HAER No. WI-21, 1987).

The Watertown bowstring probably was originally a four-span structure over the Crawfish River near Milford in Jefferson County. When it was replaced in 1906 by a single-span, 190-foot-long, Pratt overhead truss, two of the bowstring spans were relocated to Tivoli Park.[59] The bottom chord consists of two parallel, flat, iron bars hammered from large rods (the rod shape is still evident at the ends of the bars). Except for the riveted plates of the upper chord, pin connections secure the joints. The posts, "T" in section, extend through holes in the upper chords, secured at the ends by nuts with cast-iron washers. The diagonal and bottom lateral bracing consist of cylindrical rods with threaded ends. U-bolts hold cross beams against the lower chords. Extending beyond the sides of the bridge, floor beams support longitudinal, rolled I-beams. The oversize floor beams may indicate a former sidewalk.

A homegrown variation of the bowstring, called the "tubular bridge," was apparently common in some parts of Wisconsin before World War I, although none survive. According to Hans Nelson Brue, writing in 1916:

> Tubular bridges...were constructed of three or four inch iron pipe connected up with standard fittings to form trusses. In spans ranging from thirty to sixty feet they are quite common in Dane County, several types being invented by Mr. Knut Knudtson of DeForest. These bridges were satisfactory for light loadings and were easily constructed, but under heavier loadings they give dangerously large vibrations. Their chief weakness lies in the lack of lateral bracing for the trusses.[60]

Brue also noted that the timber king post truss was "quite common" in "some sections" of Wisconsin.[61] The king post is the simplest form of truss, but one of the least flexible in terms of the

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[59] Kromm, "Milford Bridge" 2-4. The original plans of the Pratt truss, built by the Wisconsin Bridge and Iron Company, are on file at the Milford Town Hall.

[60] Brue, 13.

[61] Brue, 5. Since Brue uses the term "timber A-frame trusses" it is uncertain whether he is referring to a traditional King Post or to a late nineteenth-century, modification known as a "Waddell A Truss," which is a King Post with subdiagonals (see Figure 26); Waddell, Bridge Engineering, 478.

ratio between span length and the height, or depth, of the truss. King posts with a span greater than 50 feet, for example, require extraordinary lateral bracing for stability. According to Brue, the configuration was generally employed for "spans ranging from twenty to thirty feet,"[62] which characterizes a surviving king post in Bayfield County (P-04-043), the Lakeview Bridge. This bridge is a combination truss with steel-rod verticals tying together timber upper and lower chords. Surprisingly, it was built in the early 1950s. Its designer was a local contractor, who modeled his work after a much older (and since demolished) bridge in the region.[63] The state's only other remaining example of king post bridge design is an all-metal structure in Port Washington, Ozaukee County (P-45-714), Sauk Creek Bridge. Dating at least from the 1920s, this bridge has a 40-foot span.[64] Another all-metal example located in Polk County was removed at an undetermined date (see Figure 19). Another early bridge truss, the queen post, is a lengthened version of the king post. The state's only remaining example is the Taylor Bridge (P-16-097) in Douglas County.[65]

The two truss designs that came to dominate bridge construction by the late nineteenth century were the Warren and the Pratt. The Warren truss was patented by two British engineers in 1840. In this design, the vertical members handle only nominal stress, while the diagonals serve as both tension and compression members. The vertical members, like the diagonals, were usually paired angles, but of smaller dimension. In Wisconsin, Warren trusses are by far the most common type of highway truss, although the only remaining nineteenth-century examples are former railroad bridges that were relocated to town roads (Poplar Grove Bridge, P-14-125, and Scofield Road Bridge,

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[62] Brue, 5.

[63] An almost identical king post (P-04-044) was built simultaneously on the same stretch of road by the same contractor; it was replaced in 1988; see "Inventory Forms" for P-04-044, P-04-043 in Part 2: Appendix of this study.

[64] The Sauk Creek Bridge (P-45-714) was replaced in 1988. An Historic American Engineering Record report (HAER WI-40) was prepared.

[65] For additional information see the intensive survey form for P-16-097 in Part 2: Appendix of this study.

Figure 19: All-metal king post truss, Polk County, 1950; demolished. In this bridge, the traditional king post design has been modified with sub-diagonals, forming a variant known as a "Waddell A Truss." (Source: SHC files, WisDOT).

P-14-126, both relocated to the town of Lebanon, Dodge County).[66] The Warren is also one of the most homogeneous truss types. Of the approximately 500 Warren trusses in Wisconsin in 1980, over four-fifths were riveted pony trusses built according to SHC standard plans (see Figure 20).

The Pratt truss, patented by Caleb and Thomas Pratt in 1844, features vertical compression members and diagonal tension members. Although originally built as a combination bridge, the Pratt truss was not as efficient in that form as the Howe. As an all-metal bridge, however, the advantage lay with the Pratt, which used less iron and was easier to erect (see Figure 21). During the 1870s, an important variation of the Pratt design was introduced for long-span bridges. Because the depth of truss required in the center of a bridge is greater than at the abutments, a considerable amount of material can be saved on a long-span structure by "bending" the top chord into a polygonal configuration. The resultant form is known as a "Parker" truss. If the top chord has exactly five sides, the bridge, by convention, is called a "camelback" truss (see Figure 22).

A further variation is the Pennsylvania truss, introduced in 1875 by the Pennsylvania Railroad as a "major advance in strengthening the Pratt truss" to meet the challenge of increasingly heavier locomotives and rolling stock. The Pennsylvania design also had a polygonal top chord for economy of material, but it added panel subties, or substruts, for greater strength and rigidity. In the United States, Pennsylvania highway trusses are generally designed for spans between 250 and 600 feet in length.[67] The longest Wisconsin example is the pin-connected 1908 Cobban Bridge (B-09-965), which has two Pennsylvania spans of 241 feet (see Figure 23). The seven Pennsylvania spans of the 1931 Bridgeport Bridge (B-12/22-850) are only slightly shorter, each measuring 232 feet.[68]

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[66] Both bridges were relocated again in 1996.

[67] Comp and Jackson, 5-7; Waddell, The Designing of Ordinary Iron Highway Bridges, 25, 268, 469, and 478; Waddell, Bridge Engineering, 176-177; Johnson et al., The Theory and Practice of Modern Framed Structures, 275; Ketchum, 212; Tyrrell, History of Bridge Engineering, 184-192.

[68] The Bridgeport Bridge was determined eligible for the National Register before being removed in 1989.

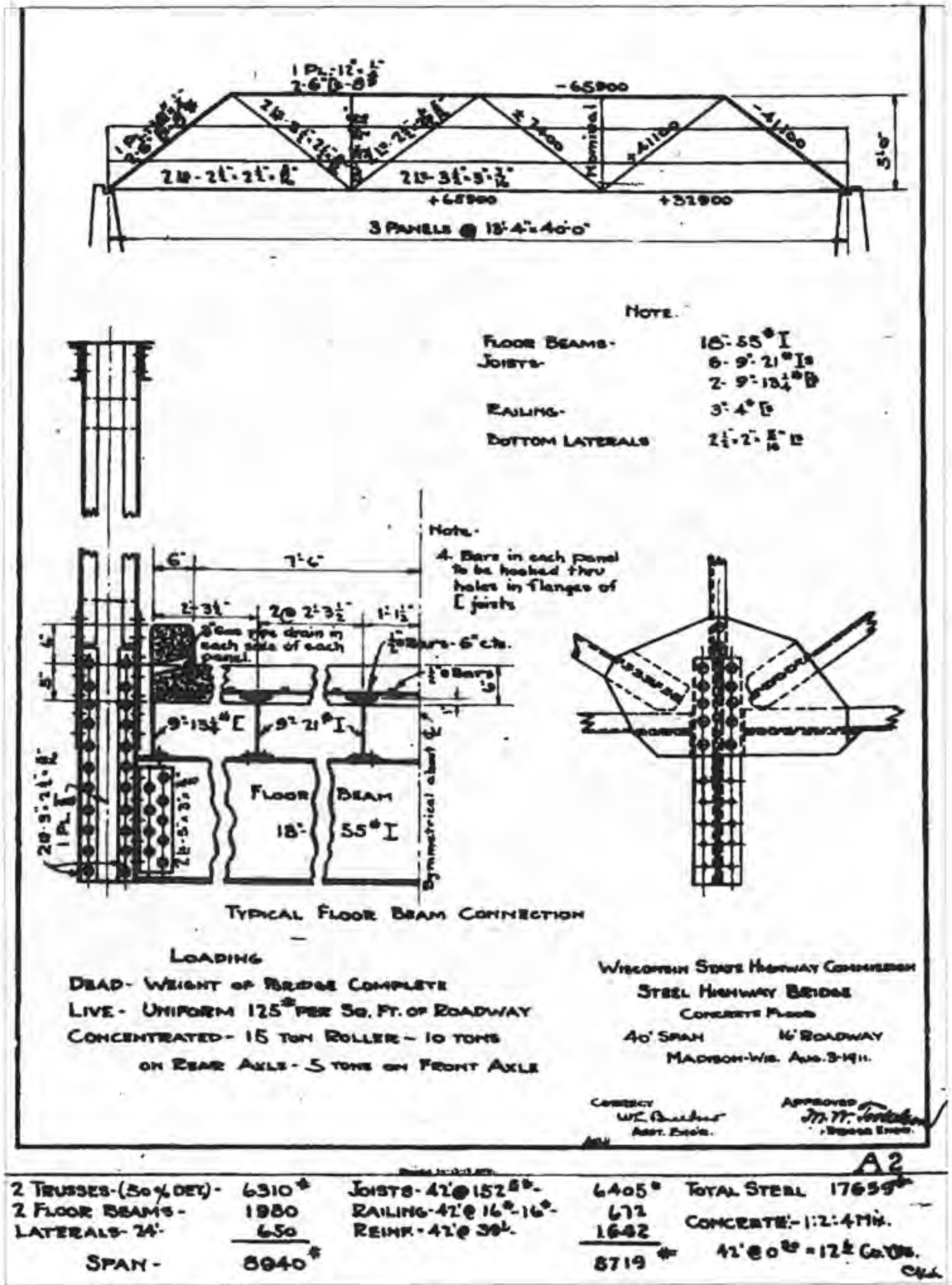

Figure 20: SHC standard plan for riveted, Warren, pony truss with 40-foot span, 1911. (Source: WisDOT).

Figure 21: Overhead Pratt truss, River Falls, Pierce County; built in 1876 by Wrought Iron Bridge Company. The double-intersection counters are an unusual feature. (Source: Shepherd Collection, Area Research Center, University of Wisconsin -- River Falls).

Figure 22: Manchester Street Bridge (P-56-713), Baraboo, Sauk County. Erected by the Milwaukee Bridge and Iron Works in 1884, this camelback truss was moved to a city park in 1987. (Source: Robert M. Frame III, Field Inventory Photograph, 1986).

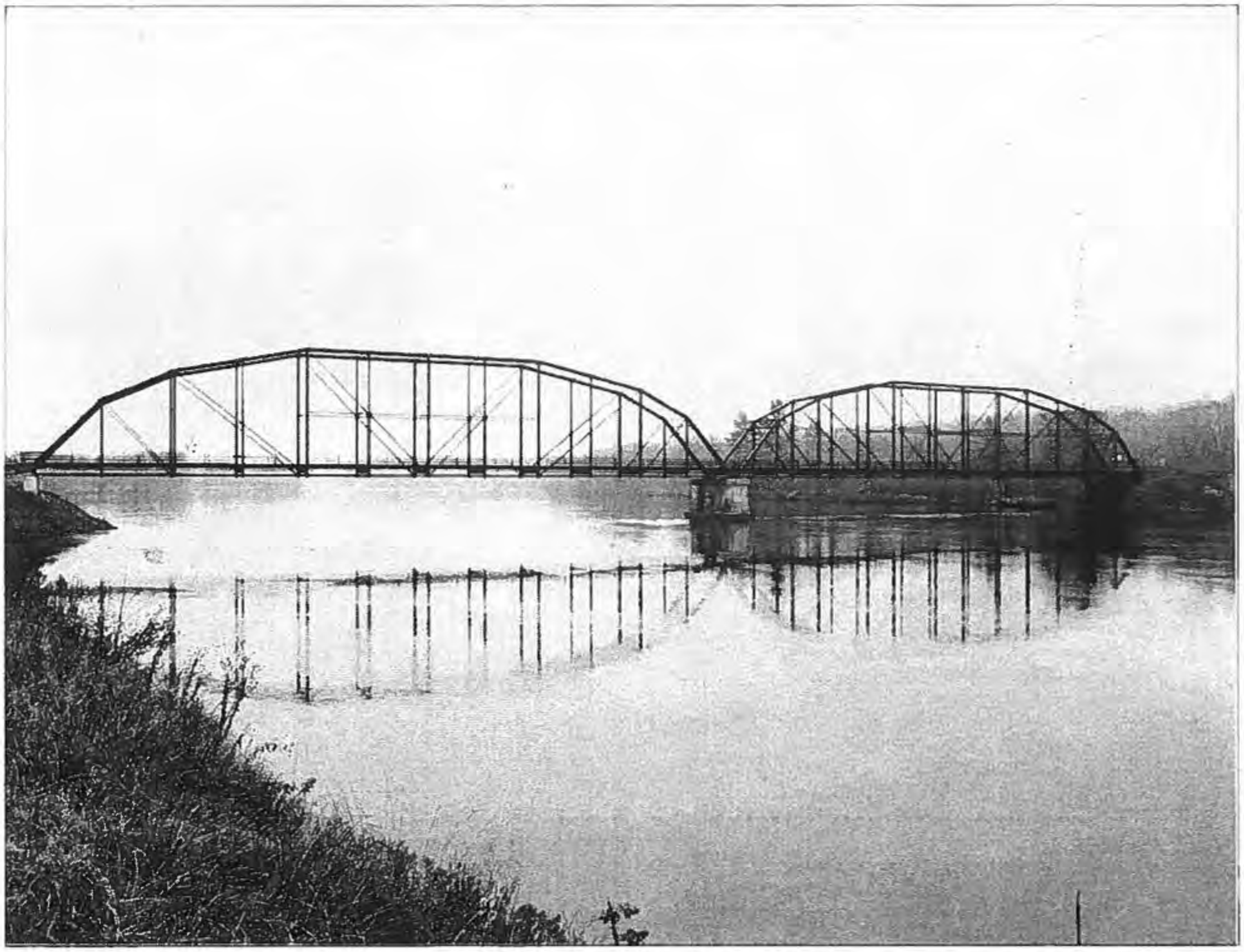

Figure 23: Cobban Bridge (B-09-965) over Chippewa River, Towns of Arthur and Eagle, Chippewa County. Originally erected in 1908 at a site about 15 miles downstream, this double-span Pennsylvania truss bridge was moved to its present location in 1919. (Source: Jeffrey A. Hess, Field Inventory Photograph, 1986).

The development of these Pratt variations was not significantly influenced by the late nineteenth-century debate over the relative virtues of iron and steel in bridge construction. Of greater consequence to bridge design than the development of these Pratt variations, was the concurrent debate over the merits of pin (see Figure 24) versus riveted connections for main truss members (i.e., batter posts, verticals, diagonals). Proponents of riveted bridges usually cited the advantages of increased structural rigidity and the reduction of damaging vibrations. In pin-connected bridges, vibrations caused the pin to grind on the eye-bar, thus enlarging the pin hole. According to one observer, some bridges had to be replaced on that account alone. Advocates of pin-connected bridges, on the other hand, emphasized the theoretically correct distribution of stresses and the smaller amount of metal required. They also criticized the difficulty of ensuring that a riveted joint was properly fabricated, especially in the field. The pin-connected bridge, they argued, was the reason why Americans surpassed the rest of the world in bridge building.[69]

The issue of pin versus riveted connections was complicated by practical factors, including machinery, tools, and power sources, both in the shop and in the field. In addition, both connection types came to incorporate features that were not an intrinsic part of the design. Many riveted spans, for example, used the lattice girder (or multiple triangulation) design, which was clearly excessive in material, while many pin-connected bridges were dangerously light, particularly in their details. Thus, a fair comparison between the two systems was not always made.[70]

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[69] Waddell, Economics of Bridgework, 73-74; Alfred P. Boller, Practical Treatise on the Construction of Iron Highway Bridges, 4th ed. (New York: J. Wiley & Sons, 1890), 44-49; "Discussion of American Railroad Bridges," Transactions of the American Society of Civil Engineers 21 (Dec. 1889): 593.

[70] Waddell, Economics of Bridgework, 7; "The Development of Bridge Trusses," Engineering Record 42.18 (1900): 411. Inventor Charles Horton, for example, patented an ingenious alternative to both systems. However, it appears to have been put to its greatest practical use by Horton and the La Crosse Bridge Company, which bought his patent rights. The McGilvray Road Bridges in the Van Loon Wildlife Area near La Crosse, are some of the best examples in the state; see Diane Kromm, "McGilvray Road Bridge No. 1," Historic American Engineering Report, HAER No. WI-22, 1987 (see Figure 25).

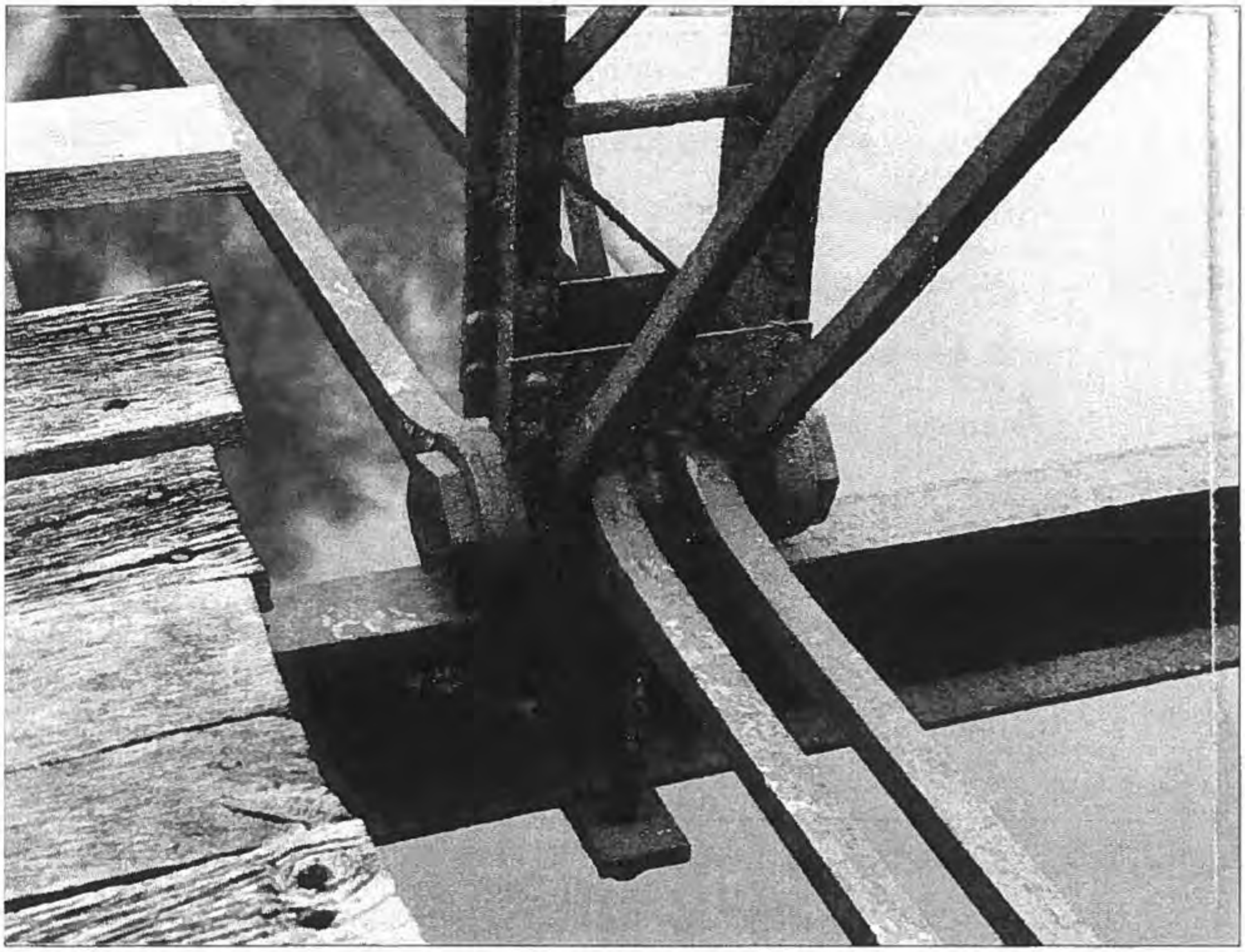

Figure 24: Pin-connection detail of an overhead Pratt truss erected in 1877; photograph shows vertical post, bottom chord, eye-bars, and floor-beam hanger; White River Bridge, Burlington, Racine County. (Source: HAER No. WI-16).

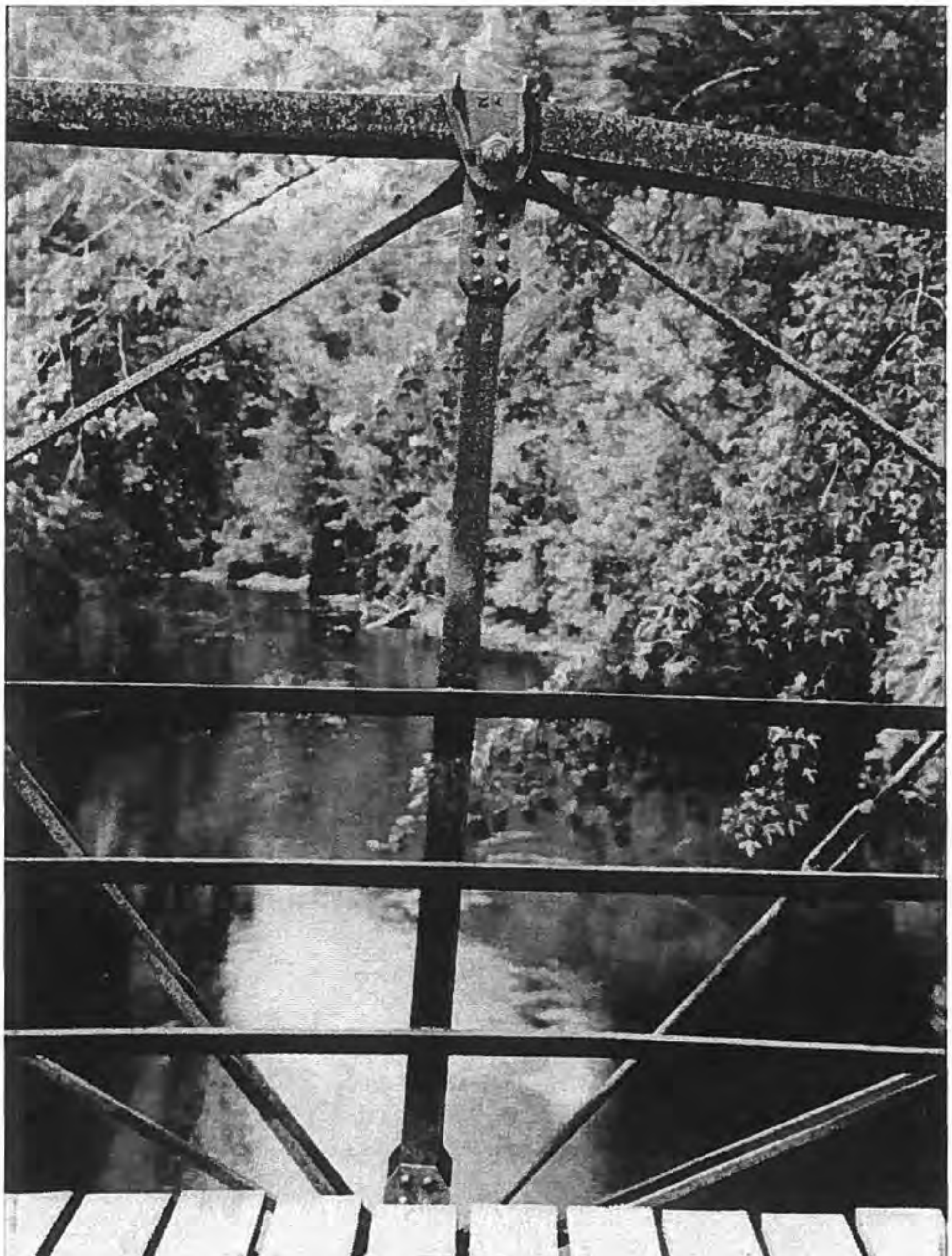

Figure 25: Detail of Charles M. Horton's patented, hanger hook-clip; McGilvray Road Bowstring Truss Bridge No. 1, Van Loon Wildlife Area, La Crosse, Wisconsin. (Source: HAER No. WI-22).

According to Waddell, the controversy raged in engineering circles for a dozen years around the turn of the century. No dramatic resolution of the issue occurred, but "time and steady development of the real science of bridge designing" gradually changed minds. Significant changes in riveting technology also altered the terms of the debate (see Figures 26 and 27).[71] A compromise of sorts was finally reached, resulting in the adoption of riveted connections for short spans and pin connections for long spans. Bridges with all-riveted joints were favored for short spans, while those with pin-connected chord joints were still accepted for long-span highway bridges. Even Waddell, often acerbic in rejecting an opposing view, acknowledged in 1921 that "a pin-connected highway span of five hundred, or even four hundred feet, does not make a bad bridge."[72]

In Wisconsin, state highway officials clearly favored riveted construction. Consequently, the distinction between pin and riveted connections establishes an important boundary, separating the era of state-planned bridges from the preceding period in which bridge companies were largely responsible for bridge design. As early as 1908, state engineers advocated the use of riveted Warren and Pratt pony trusses for short-span bridges.[73] When the SHC was formally established in 1911, the riveted Warren became the state's standard pony design (see Figure 20). In that year, the SHC also drafted a standard plan for riveted, overhead, Pratt trusses (see Figure 28), and by 1914, the agency had adopted riveted construction for all overhead Pratt variations. As SHC engineer A. R. Hirst explained:

> Spans from 40 to 80 ft. – We are using the Warren riveted pony truss practically exclusively, though a few plate girders are being used where the conditions of hauling

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[71] Charles Fowler, "Some American Bridge Shop Methods," Cassiers Magazine 17.4 (1900): 200-215; and Charles Fowler, "Machinery in Bridge Erection," Cassiers Magazine 17.4 (1900): 327-344; "Pneumatic Percussion Riveters," Engineering News 3 Mar. 1898: 148-149; "Field Riveting by Power," Engineering Record 42.17 (1900): 385.

[72] Waddell, Economics of Bridgework, 74; Danko, "Development of Bridge Trusses," 411.

[73] The state's standard plan (dated 1908) for a riveted Warren pony truss with 40-foot span is found in Microfilm Reel M-1, "Miscellaneous Standards," Bridge Section, Central Office, Wisconsin Department of Transportation.

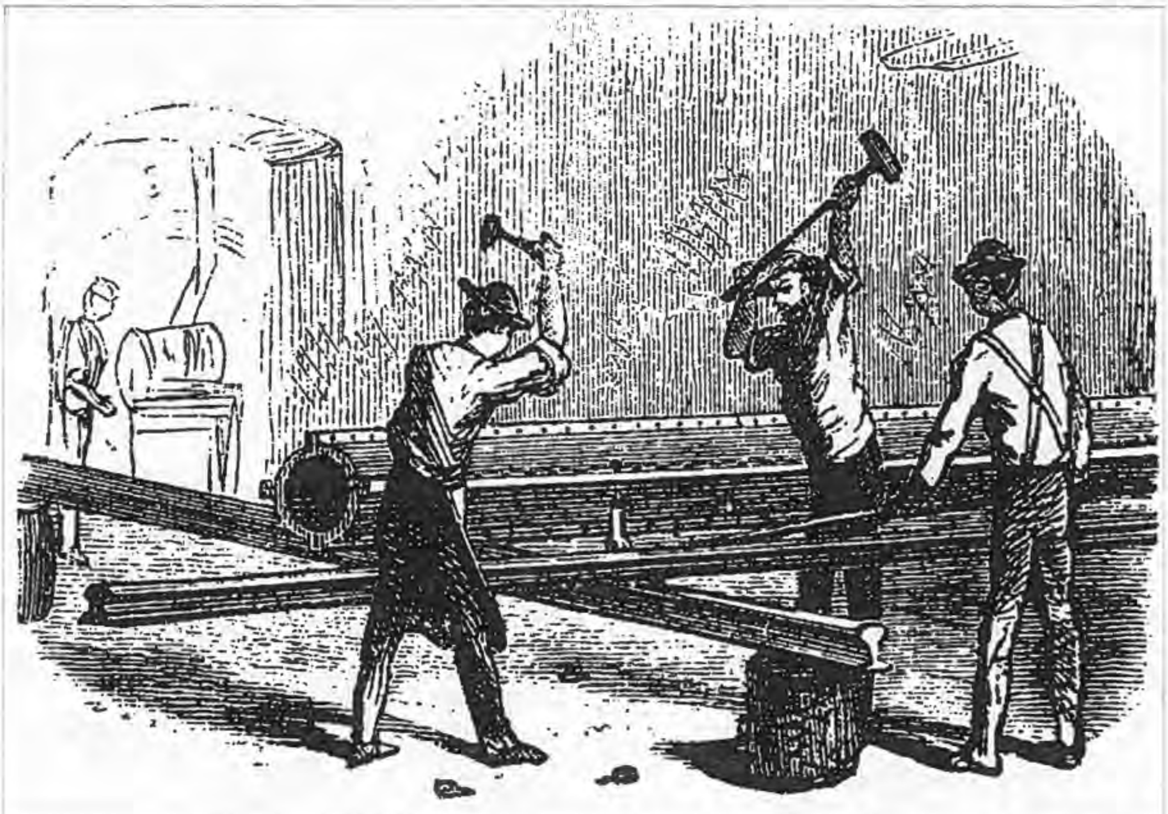

Figure 26: Shop riveting a column, c. 1872. (Source: Victor C. Darnell, Directory of American Bridge-Building Companies, Washington, D.C., 1984, p. 47).

A PNEUMATIC HAMMER DRIVING ⅞-INCH RIVETS ON CHICAGO ELEVATED RAILWAY. MADE BY THE CHICAGO PNEUMATIC TOOL COMPANY, CHICAGO

Figure 27: Field riveting, c. 1900. (Source: Charles Evans Fowler, Machinery in Bridge Erection," Cassiers Magazine, 17 [February 1900], 336).

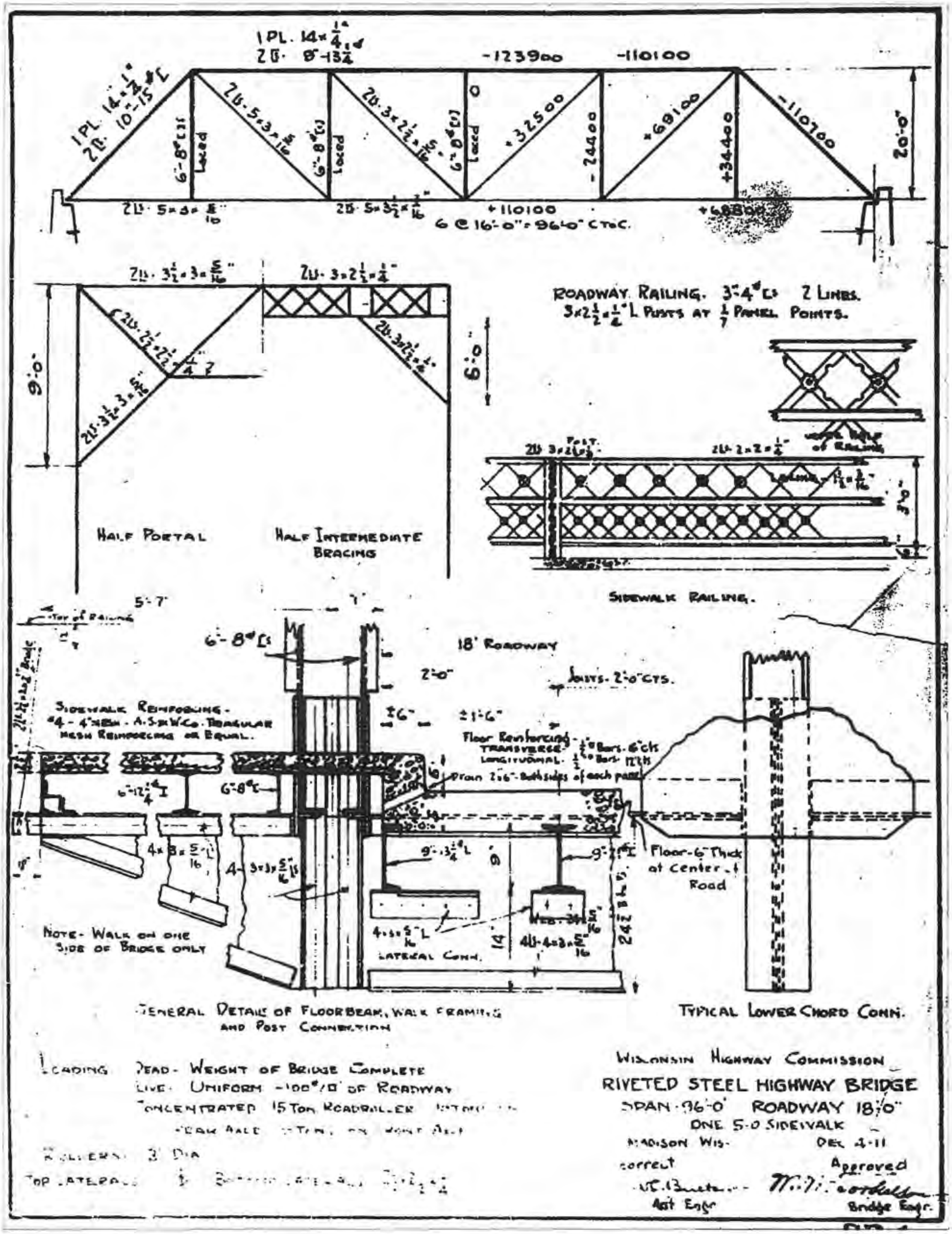

Figure 28: SHC standard plan for Pratt overhead truss with 96-foot span, 1911. (Source: SHC files, WisDOT).

> are favorable. All of these structures have concrete floors...
>
> Spans from 80 to 135 ft. – We use the riveted Pratt high [i.e., overhead] truss with a horizontal top chord, also with a reinforced-concrete floor...
>
> Spans over 135 ft. – We use a Pratt riveted high truss with a curved [i.e., polygonal] top chord. practically all of these larger spans are also built with a reinforced concrete floor. Very seldom do we use a pin-connected truss...
>
> Spans over 135 ft. – We use a Pratt riveted high truss with a curved [i.e., polygonal] top chord...Very seldom do we use a pin-connected truss...[74]

The SHC's preference for riveted construction coincided roughly with the rise of the automobile, which demanded heavier bridges. A pronounced trend toward more substantial, uniform construction can be seen in other aspects of bridge design as well. In pre-1895 overhead Pratts, for example, the beams were built up from plates and angles, the tension members and the top lateral struts were light, and the deck was wood. These bridges often featured considerable ornamentation (see Figure 29). From 1895 to 1910, built-up floor beams were generally replaced by a rolled section, while the hip verticals became thicker and the top lateral struts deeper, sometimes augmented by knee bracing. During this era, some bridges used a more substantial bottom chord such as channel beams, while others continued to use rather light, loop-welded, eye-bars (see Figure 30). When the SHC was established in 1911, it advocated the use of paired angles for the bottom chord, along with concrete floors, deep portal bracing, and stiff top lateral struts with knee bracing. By the late 1920s, SHC plans called for angles or built-up members for the hip verticals, counters, and diagonals (see Figure 31). By the early 1930s, the agency had adopted the rolled section for most main members and laced angles for portal bracing and sway struts (see Figure 32).

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[74] A. R. Hirst, "Bridges and Culverts for Country Roads," Engineering News 9 Oct. 1913: 729. With minor modifications, these standards are reiterated in the Wisconsin State Highway Commission, Second Biennial Report, 24. It was not until 1963 that AASHTO provided complete specifications for a welded bridge. Shortly thereafter, riveting rapidly disappeared, replaced by welding and high strength bolts; see Federal Highway Administration, Design and Construction, 1 and 6-9.

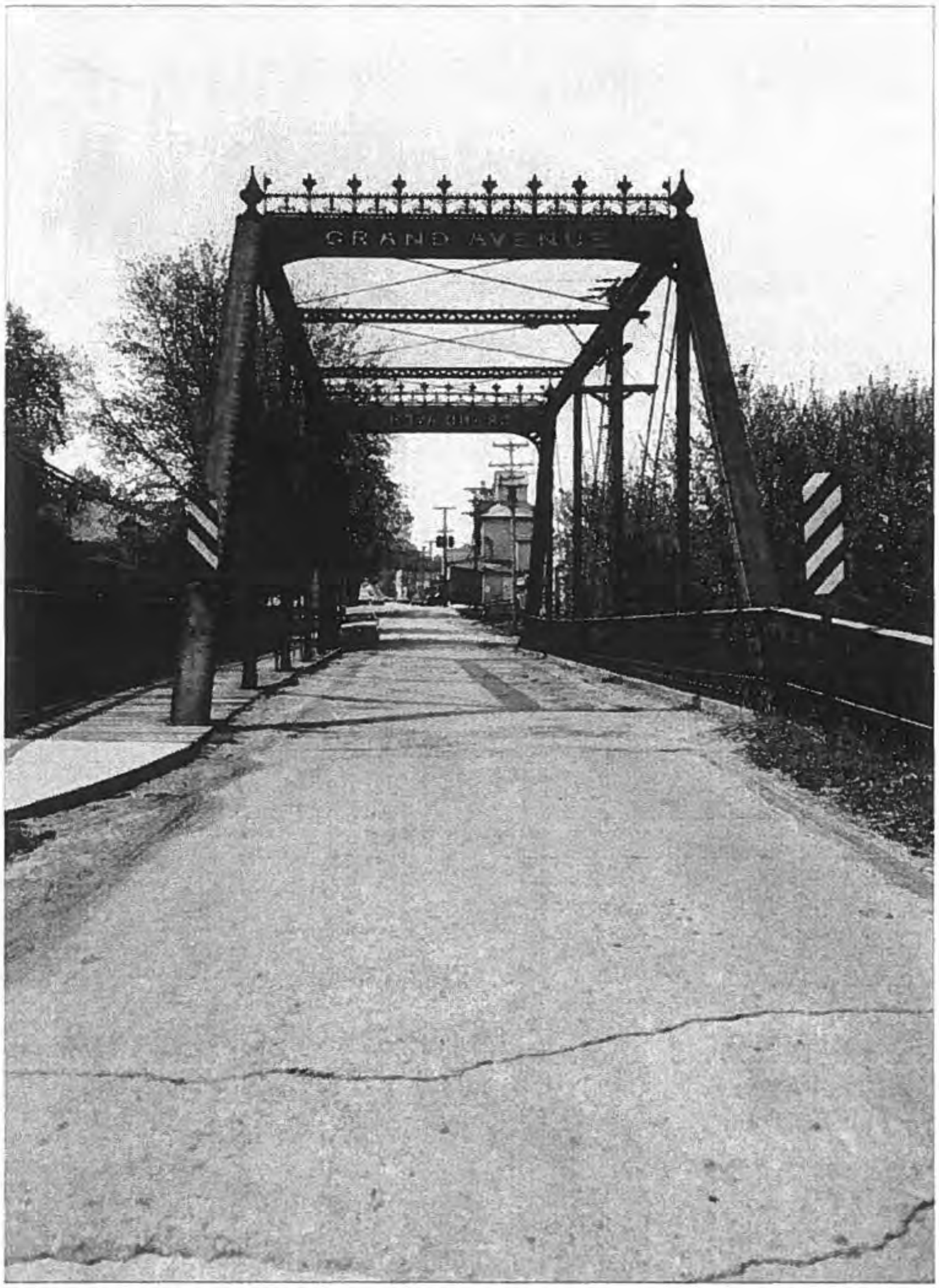

Figure 29: Grand Avenue Bridge, Neillsville, Clark County; overhead Pratt truss, erected 1894; replaced 1986. (Source: HAER No. WI-72).

Figure 30: Ferndale Road Bridge (P-38-096), Towns of Lake and Grover, Marinette County; overhead Pratt truss, erected 1910 by Elkhart Bridge and Iron Company. (Source: Robert M. Frame III, Field inventory photograph, 1986).

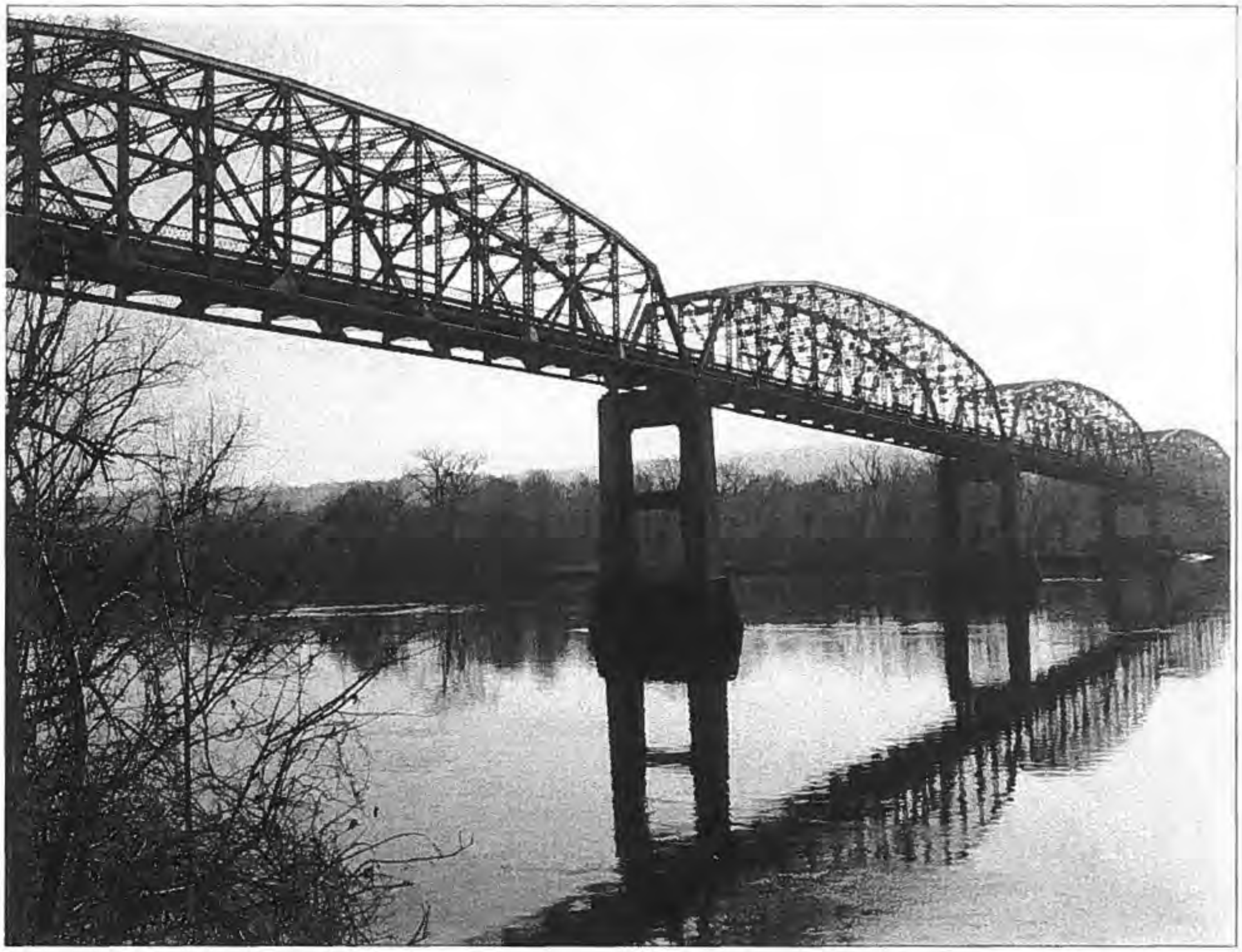

Figure 31: Bridgeport Bridge (B-12/22-850), Town of Wyalusing, Grant County; seven-span Pennsylvania truss, erected 1931. (Source: Robert M. Frame III, Field Inventory Photograph, 1986).

Figure 32: Coulthard Bridge (B-33-204), Town of New Diggings, Lafayette County; double-span overhead Pratt truss, erected 1935. (Source: Robert M. Frame, Field Inventory Photograph, 1986).

An important detail of all-metal bridges is the expansion bearing.[75] Since metal expands and contracts with changes in temperature, it is necessary to provide for this movement, especially in long-span structures. Durability presents the greatest challenge in the design of expansion bearings. The simplest method, often used on Wisconsin pony trusses, was to provide two flat, smooth surfaces with a bolt or pin in a slotted hole to guide the movement between these surfaces. To reduce friction, the sliding plates were greased with tallow or some other lubricant. Bearings of this design had a relatively short life span, quickly accumulating dirt and eventually corroding into immobility. Over the years, different lubricants and metals have been tried, including, most recently, stainless steel and Teflon. But none has proven invulnerable to dirt and corrosion. Good maintenance thus remains a necessity for effective expansion-bearing operation.

The next development in expansion-bearing design involved the use of horizontal cylinders enclosed in a metal housing, forming a device known as a "roller nest" (see Figure 33). Although rollers varied in diameter from one to nine inches, the smaller sizes were more vulnerable to grit while the larger sizes tended to develop flat spots. When the SHC drafted a standard roller-nest plan in 1913, it specified a three-inch-diameter roller (see Figure 34). The plan also stipulated that "roller boxes shall be dust proof and filled with oil which will not congeal." In practice, however, roller nests inevitably collected dirt. Searching for a more efficient expansion bearing, the SHC in 1915 switched to the exposed "rocker," which, in a sense, comprised part of the arc of a very large roller. This device appears to have remained the agency's preference until at least World War II. One obvious advantage of this design was that maintenance was simple (Figure 35).[76]

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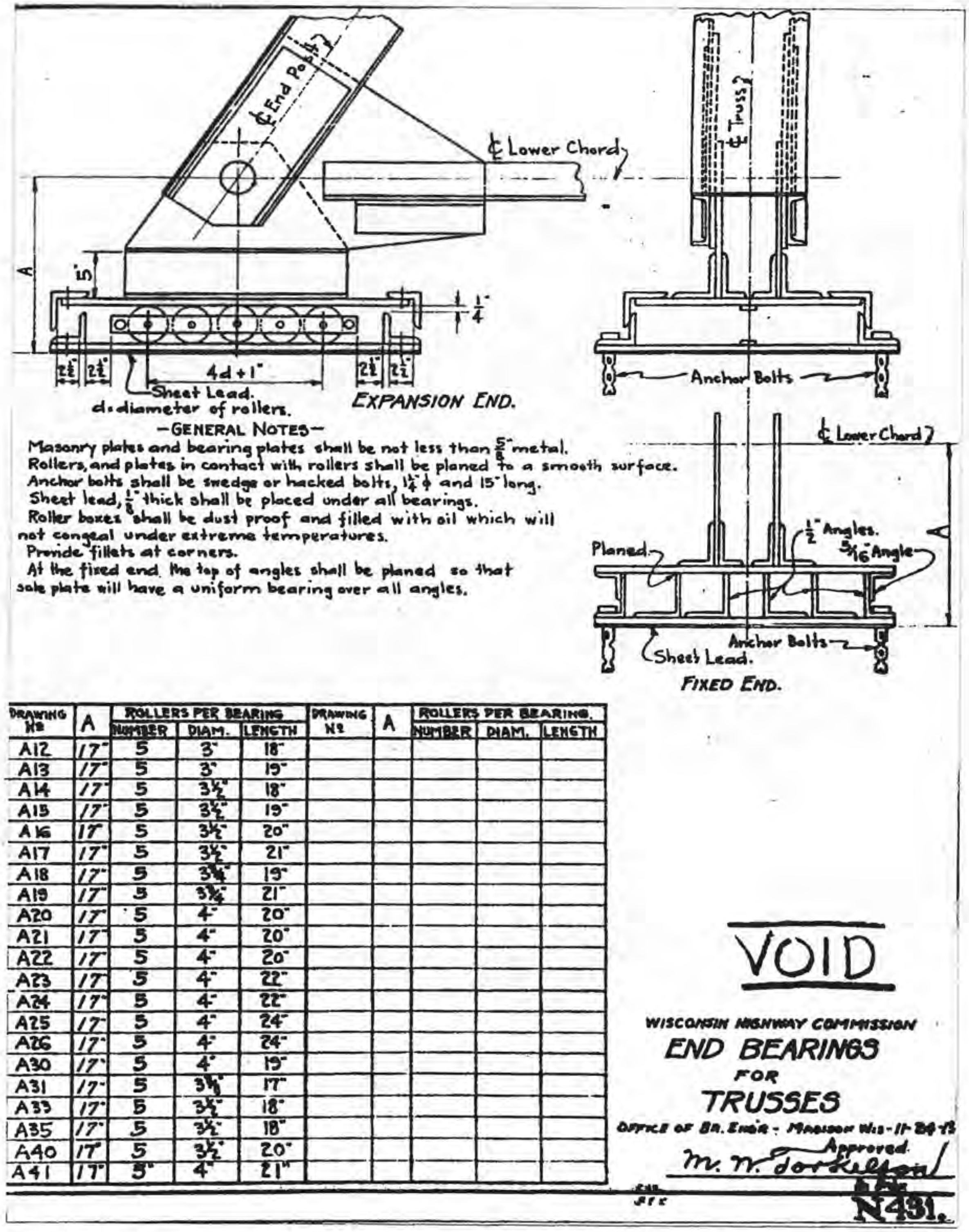
[75] This discussion of expansion bearings draws heavily on National Cooperative Highway Research Program, "Bridge Bearings," Synthesis 41 (Washington, D.C.: Transportation Research Board, 1977), 3-4, 13, and 17-26.

[76] An unusual expansion bearing, combining elements of both roller nest and rocker, was incorporated into the Dorham Road Bridge (P-14-071) over the East Branch of the Rock River in Dodge County. The device consists of three pairs of small rockers in a partially open housing. The construction date and the origins of the design are unknown. The bridge was replaced in 1986.

Figure 33: Detail of roller nest expansion bearing, White River Bridge, Burlington, Racine County; erected 1877. (Source: HAER No. WI-16).



DRAWING No	A	ROLLERS PER BEARING			DRAWING No	A	ROLLERS PER BEARING.		
		NUMBER	DIAM.	LENGTH			NUMBER	DIAM.	LENGTH
A12	17"	5	3"	18"					
A13	17"	5	3"	19"					
A14	17"	5	3½"	18"					
A15	17"	5	3½"	19"					
A16	17"	5	3½"	20"					
A17	17"	5	3½"	21"					
A18	17"	5	3¾"	19"					
A19	17"	5	3¾"	21"					
A20	17"	5	4"	20"					
A21	17"	5	4"	20"					
A22	17"	5	4"	20"					
A23	17"	5	4"	22"					
A24	17"	5	4"	22"					
A25	17"	5	4"	24"					
A26	17"	5	4"	24"					
A30	17"	5	4"	19"					
A31	17"	5	3⅛"	17"					
A33	17"	5	3½"	18"					
A35	17"	5	3½"	18"					
A40	17"	5	3½"	20"					
A41	17"	5"	4"	21"					

Figure 34: SHC standard plan for roller nest expansion bearing, 1913. (Source: SHC files, WisDOT).

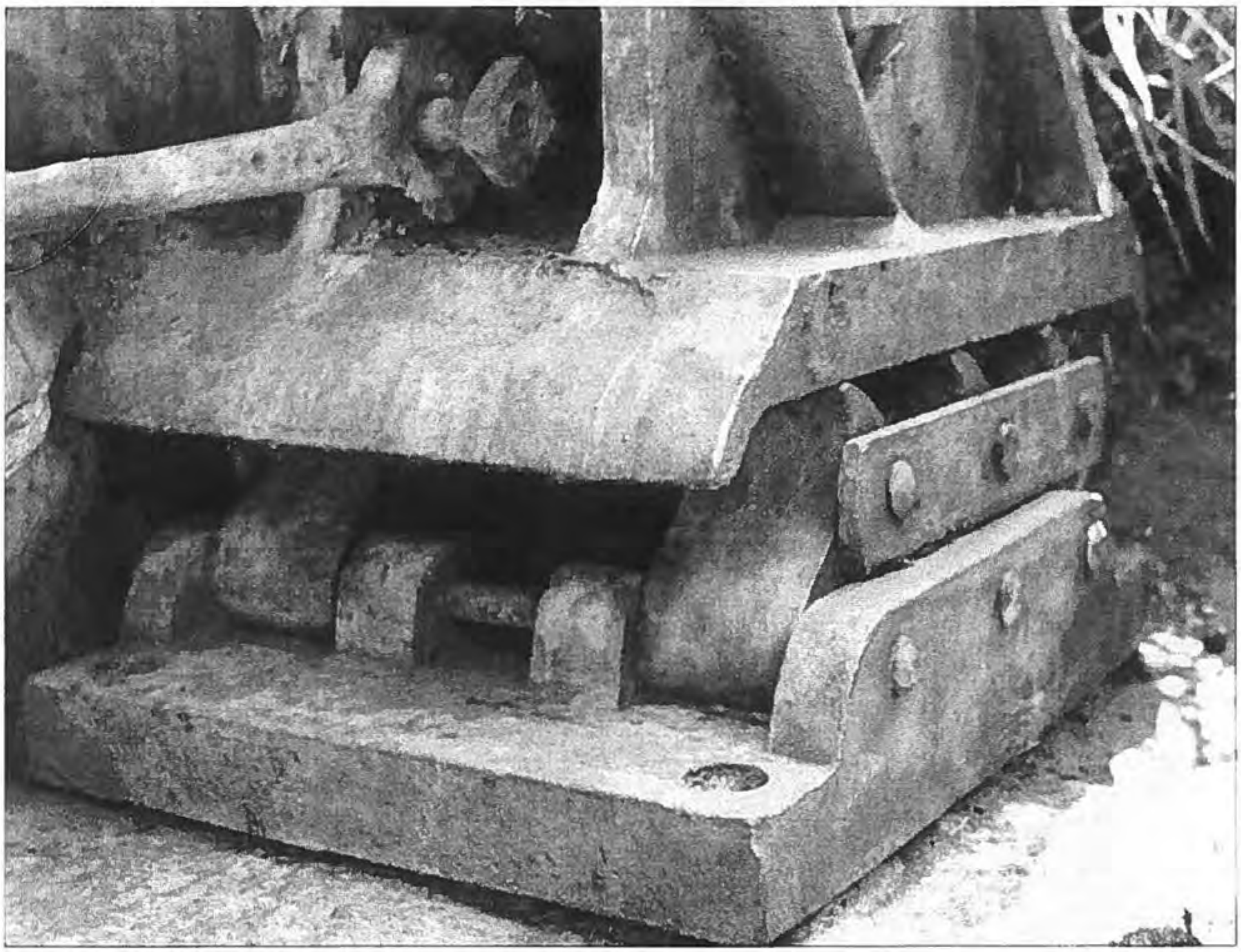


Figure 35: Rocker nest expansion bearing, Gill Road Bridge, Dodge County. This unusual bearing combines the attributes of the rocker and roller nest designs. (Source: SHC files, WisDOT).

Fabrication and Erection

No doubt, many early wood trusses were fabricated on, or very near, the crossing and were erected primarily by hand labor and hand tools. But by 1900, iron bridges were mass produced at factories, transported to the site in varying degrees of assembly, and then erected by trained crews. Machinery was increasingly prevalent in both the manufacturing and erection operations, and well-equipped, experienced crews had an increasing advantage over local labor, as "labour-saving devices...[were] practically indispensable."[77]

Nevertheless, a certain "folk" mythology persists in equating metal-truss construction with the barn raisings of the pioneer period. As one study unequivocally states: "Back in the 1890s when the residents of a rural Wisconsin township decided that they needed a new bridge, they looked over bridge manufacturers' catalogues, picked out the bridge they liked best, and ordered it. They also got to put it together, because the bridge would arrive completely unassembled."[78] According to this account, thousands of bridges were built in this way from the 1880s to the 1930s, especially during winter months, when frozen rivers provided solid footing and farmers had time for community projects.

Although the image of the practical, self-reliant farmer may be an attractive one, it may have been more the exception then the rule. The riveted trusses that dominated medium-span bridge construction in Wisconsin by the early 1910s required substantial tools, equipment, and an experienced crew (see Figure 36). It is true that bridge approaches, being a continuation of other roadwork, were likely to have been constructed by local labor. The building of abutments was also familiar and manageable work for many local residents, and the Wisconsin State Highway Division, forerunner of

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[77] Frank W. Skinner, "American Methods of Bridge Erection," in Johnson et al., 542; Fowler, "Machinery in Bridge Erection," 327.

[78] Rosemary Satchel, "Perspective," Ms. thesis, Univ. of Wisconsin, College of Engineering, 1982, 1.

Figure 36: Wausau Iron Works crew erecting a riveted, overhead Pratt truss, New Diggings, Lafayette County, c. 1920. (Source: State Historical Society of Wisconsin, WHi(X3)38359).

the SHC, gave its official blessing to this means of providing for a low-cost but high-quality bridge.[79] Other miscellaneous work was also occasionally performed by local farmers. When the construction of a dam on the Chippewa River in Clark County required the removal of the Cobban Bridge (B-09-965) in 1917, local farmers hauled the disassembled, double-span Pennsylvania-truss structure to a new location about 15 miles upstream. There it was reerected by a professional crew.[80]

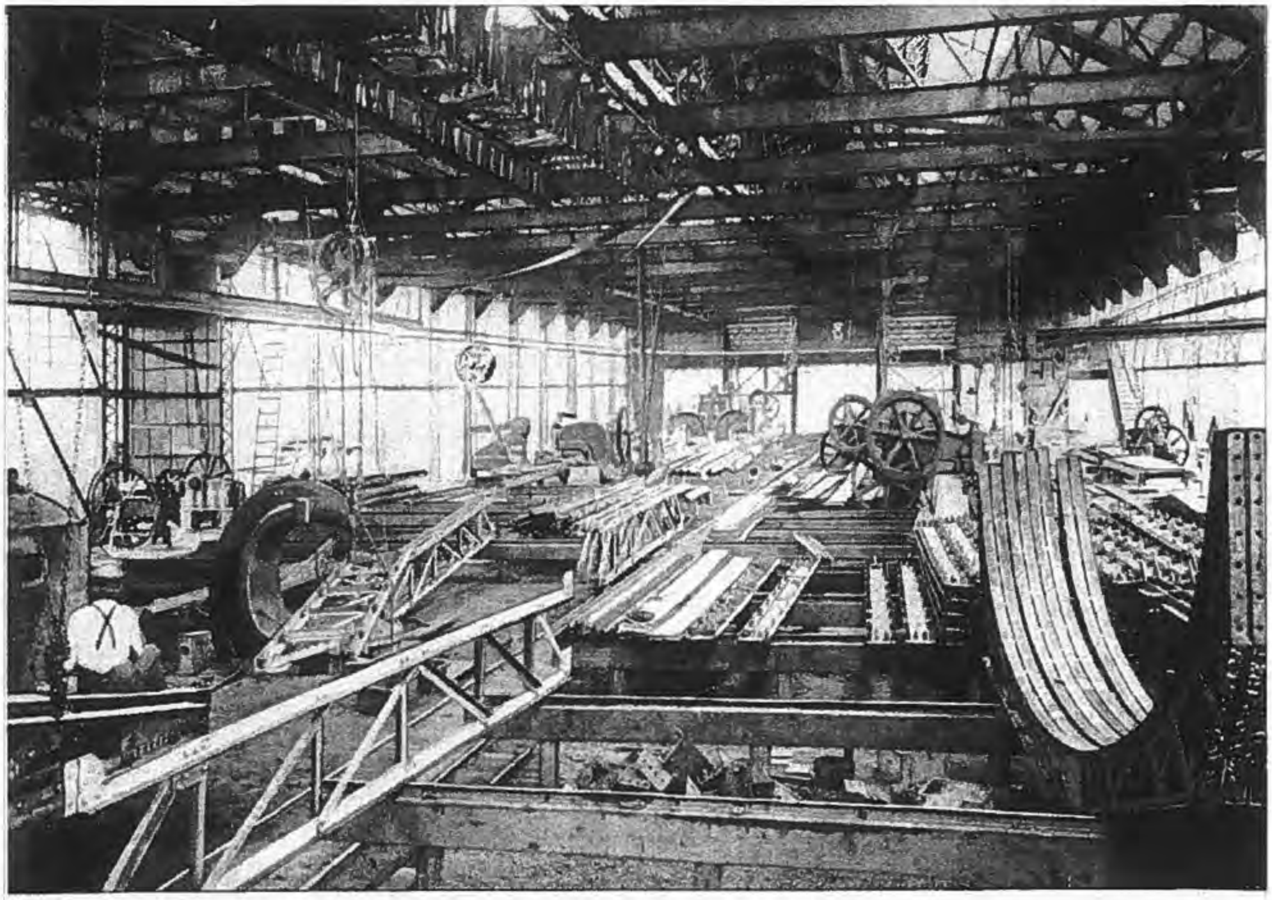
The basis for the success of American bridge companies was a specialized and compartmentalized operation housed in substantial factory buildings with modern heating, lighting, and ventilation. The separate departments customarily included shops for drafting ("detailing"), template ("templet") making, forging, machining, and riveting. The riveting shop, also called the truss shop, was the main part of the operation, combining a number of activities (see Figure 37). By 1900, American bridge companies were successfully competing world-wide, offering lower prices and faster completion than their foreign rivals.[81]

Wisconsin bridge firms seem to have adopted the industry's general pattern of separate, specialized departments. For example, an 1894 map of the Wisconsin Bridge and Iron Company's new plant in North Milwaukee depicts separate buildings for the pattern shop and "draughting" room (Figure 38). Since the main factory building was under construction at the time, the map does not show its internal layout, but later maps do identify specific locations for individual tasks, including two separate riveting areas (see Figure 39). These riveting departments may have been further specialized—so that one fabricated individual truss members while the other assembled whole trusses

[79] Arthur R. Hirst and M.W. Torkelson, Culverts and Bridges, Road Pamphlet No.4, 2nd ed. (Madison, Wis.: Wisconsin Geological & Natural History Survey, 1908), 48-49.

[80] See Intensive Survey Form for B-09-965 in Part II of this study.

[81] Fowler, "Some American Bridge Shop Methods," Cassiers Magazine 17:4 (1900): 200-02; Charles Fowler "American Bridge Shop Practice," Engineering News 21 April 1898: 257. The extent of international sales by Wisconsin bridge firms is not known. The Wisconsin Bridge and Iron Company, however, did publicize a bridge project in Guatemala; see the company's illustrated advertisement in Wright's Milwaukee Business Directory, 1893 (Milwaukee, 1893), 1118.



THE MAIN TRUSS SHOP OF THE BERLIN IRON BRIDGE COMPANY AT EAST BERLIN, CONN. A STRAIGHT-AWAY TYPE OF SHOP

Figure 37: Riveting shop (truss shop) of Berlin Iron Bridge Company, East Berlin, Connecticut. (Source: Charles Evans Fowler, "Some American Bridge Shop Methods, Cassiers Magazine, 17 [January 1900], 206).

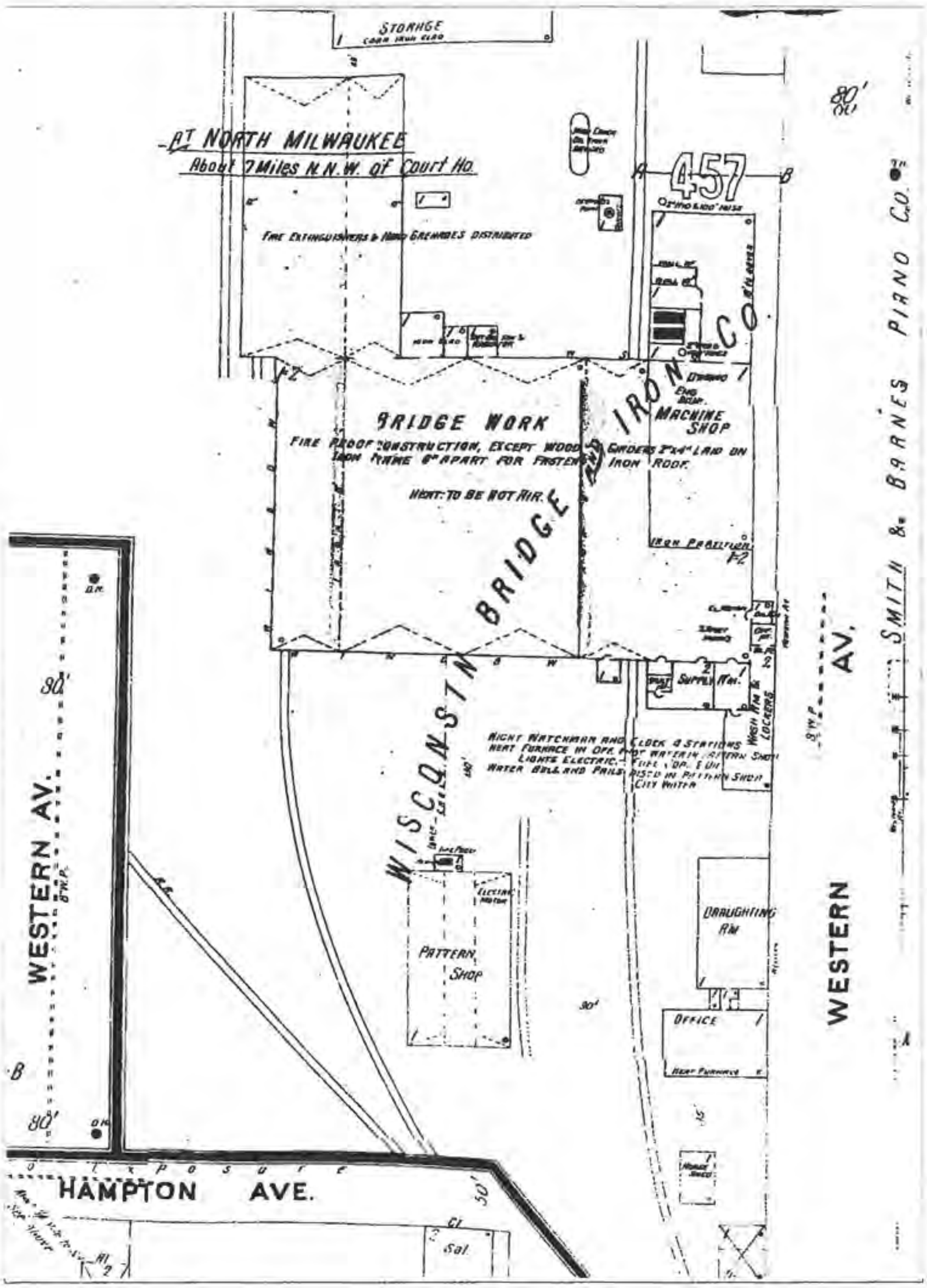


Figure 38: Plant of the Wisconsin Bridge and Iron Company, 1894. (Source: Sanborn Perris Map of Milwaukee, vol. 4, [New York, 1894], sheet 457).

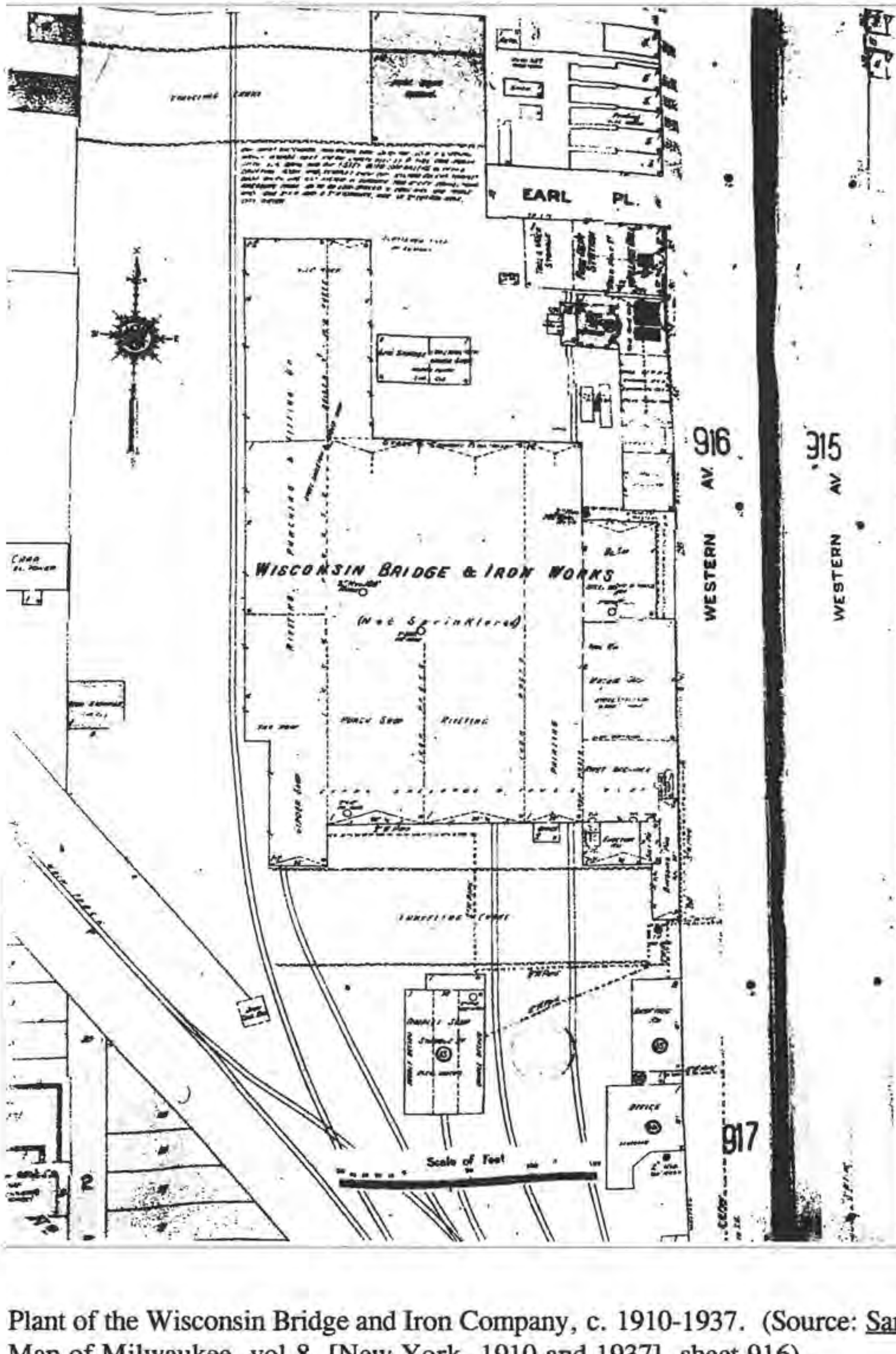


Figure 39: Plant of the Wisconsin Bridge and Iron Company, c. 1910-1937. (Source: Sanborn Perris Map of Milwaukee, vol.8, [New York, 1910 and 1937], sheet 916).

—or perhaps both areas performed the same operations, allowing the simultaneous fabrication of two complete bridges.[82] The separation and subdivision of buildings by function also characterized the plants of the Ernst Kunert Manufacturing Company, a successful Wisconsin bridge builder from 1890 to 1905, and the Milwaukee Bridge and Iron Works, which operated independently for three decades before joining with 24 other firms to form the American Bridge Company in 1901.[83]

In most large bridge plants, the sequence of manufacturing operations was essentially the same. After the bridge order was analyzed and the necessary materials procured, the plans were detailed and transferred to tracing cloth. Eye-bars, clevises, pin nuts, and other small parts were fabricated in the forge shop. The heart of the plant was the riveting shop, where the iron or steel bars were straightened and cut, and then punched or drilled; holes were reamed and ends planed as necessary. The members were then riveted together. If the bridge was a pin-connected truss, the pins were fabricated in the machine shop.[84]

Until about 1900, most plants marked the rivet spacing and other dimensions directly on each metal member. Workers checked the final product by assembling the members in the shop with bolts, reaming the punched holes for proper fit and alignment (see Figure 40). The bridge was then disassembled and shipped to the site where it was re-erected. Wausau Iron Works apparently continued this method through the 1920s. At the Worden Allen Company plant in Milwaukee, the shop erection process was streamlined by the use of a "key bolt," or slotted rivet, which was easily

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[82] According to Fowler, there were three basic organizational patterns for rivet shops: a single line or "straightaway" shop, and two forms of multiple lines of riveting work; see Fowler, "Some American Bridge Shop Methods," 201-02. No detailed accounts have been found for the shop methods of the Wisconsin Bridge and Iron Company.

[83] Sanborn-Perris Map Company, North Milwaukee, vol. 2 (Chicago: Sanborn-Perris Map Co., 1894) sheet 165; see the illustrated advertisement for Kunert in Business and Professional Directory of Milwaukee (Young and Co., 1902) n.p.

[84] Fowler, "American Bridge Shop Methods" 202-04, 207, 209.

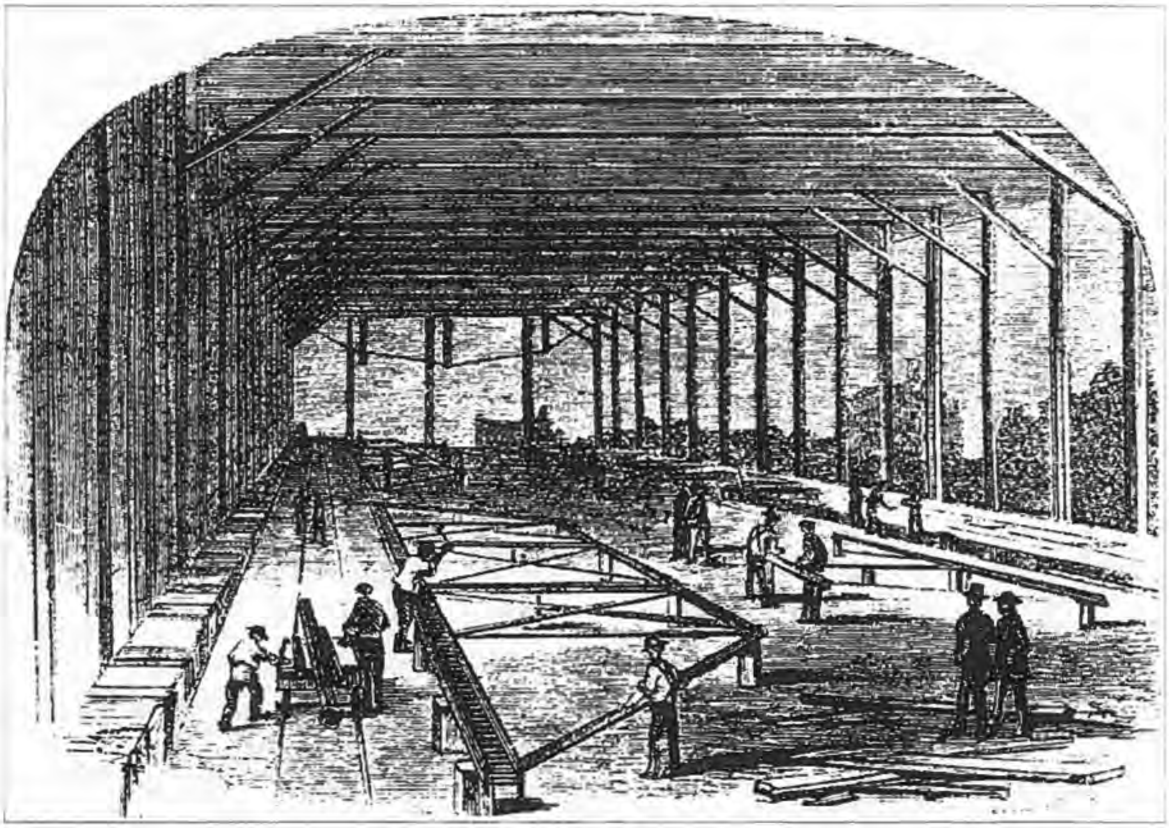

Figure 40: Trial assembly of a bridge truss in the shop, c. 1872. (Source: Victor C. Darnell, Directory of American Bridge-Building Companies, 1840-1900 [Washington, D.C., 1984]).

knocked into and out of place by means of a hammer and specially fitted key.[85] After 1900, the use of wood patterns expedited both fabrication and erection. In the template shop, pine boards were cut and drilled precisely to duplicate the full-size bridge (see Figure 41). In this system, all members with like dimensions were practically identical, since all were marked off from the same wood pattern. Thus, members of the same size were interchangeable and the first members needed for erection could be shipped as soon as they were completed, enabling fabrication and erection to overlap.[86]

In 1891, Waddell set forth the optimum crew size for ordinary, highway bridge construction as follows:

> For pony truss-bridges, six men; for through-spans not exceeding eighty feet, seven men; from eighty to one hundred feet, eight men; from one hundred to one hundred and twenty-five feet, nine or ten men; from one hundred and twenty-five to one hundred and fifty feet, eleven or twelve men...[87]

By Waddell's formula, all of the known nineteenth-century highway bridges in Wisconsin would have been built by a crew of 12 men or less.[88] By the 1890s, there were two basic organizational methods of erecting a truss bridge of any size. Either the bridge manufacturing company (or its agents) served as erector, or separate "bridge-building companies" took over this activity. Whoever was responsible, bridge erection activity was organized in three parts: the working plant, including clear space for a

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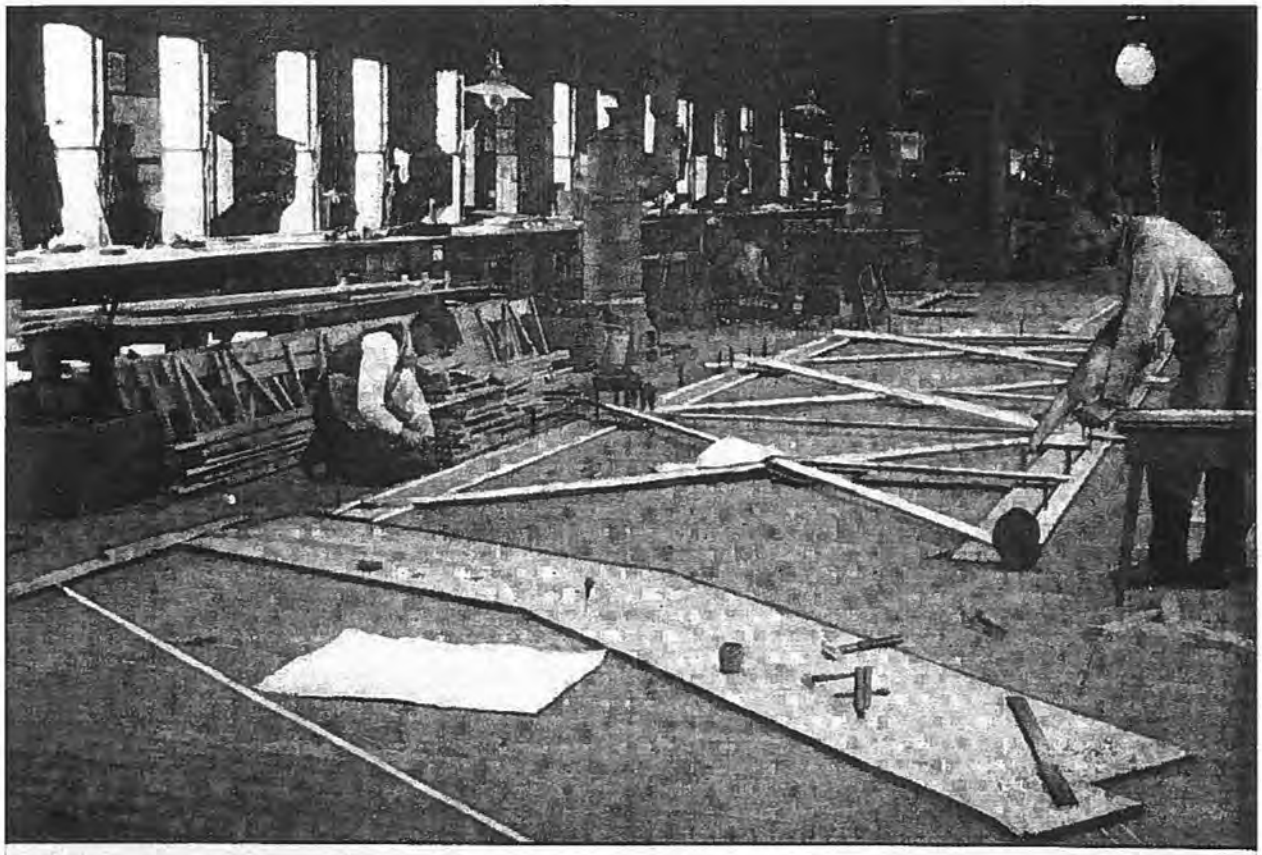
[85] George Danko, Tape Recorded Interview with Emil Krienke, former foreman of Wausau Iron Works, Tape 1, Side 1, Part 1, LOED Collection, Wisconsin State Historical Society. According to Krienke, in multiple span bridges, a member from the first span would be used to mark members on subsequent spans.

[86] Fowler, "Machinery in Bridge Erection," 329.

[87] J.A.L. Waddell, The Designing of Ordinary Iron Highway Bridges, 5th ed., (New York: Wiley, 1891), 196-97.

[88] No nineteenth-century Wisconsin highway bridge with a span exceeding 150 feet in length has been discovered. In 1890, the Milwaukee Bridge and Iron Works employed from "seven to ten gangs of from five to seventy-five men each" for erecting its bridges; see Milwaukee Sentinel, "Illustrated Description of Milwaukee," Illustrated Annual Review: Milwaukee Trades and Industries (Milwaukee, 1889), 149.



THE TEMPLET SHOP OF THE BERLIN IRON BRIDGE COMPANY, EAST BERLIN, CONN., SHOWING LAYING OUT IN PROGRESS ON THE FLOOR

Figure 41: Laying out wood patterns in the template shop, Berlin Iron Bridge Company, East Berlin, Connecticut. (Source: Charles Evans Fowler, "Some American Bridge Shop Methods, Cassiers Magazine, 17 [January 1900], 200).

staging area; the auxiliary structures, primarily the falsework; and the primary structure, namely, the bridge itself.[89]

The first task at the site was to establish a working area, which for large bridges might include temporary buildings. Ice provided an excellent working platform, and was a requirement when steel tube (or cassion) abutments were used. When it was not possible or desirable to use ice as a platform, support for the partially finished bridge was entirely provided by temporary wood structures, called "falsework" (see Figure 42). The engineering press of the period published numerous plans and illustrations of falseworks. Some of the falsework was so extensive that they required carloads of lumber and constituted temporary truss bridges in their own right. Falsework could also be quite simple. In 1883, for example, Engineering News suggested a pair of wood trestles, or "horses," for short-span bridges—a device that was still being used effectively by Wausau Iron Works some 40 years later (see Figure 43).[90]

When it was practical to do so, large sections of a bridge were shipped pre-assembled to the bridge site. Depending on the location and the era, the means of transportation for these spans varied from horse and wagon to railroad to motor truck (see Figures 44 and 45).[91] Pre-assembly not only facilitated fabrication efforts, it also made the erection process less expensive by simplifying the falsework, and in some cases, by eliminating it altogether. Generally, a truss bridge was erected with the aid of a hoist to lift materials and members into place. There were three major kinds: gin pole, derrick, and traveler.

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[89] Skinner, "American Methods of Bridge Erection."

[90] See "False Works in Bridge Erection," Engineering News 24 Mar. 1883: 136; Skinner, "American Methods of Bridge Erection"; Fowler, "Machinery in Bridge Erection," 331. On the use of ice as a platform, see Danko, interview with Krienke, Tape 1, Side 1, Part 1 and Tape 3, Side 1, Part 1.

[91] See for example, C.R. Weymouth, "Barton Bridge," Badger Highways 1.3 (1925): 5-6; "Shipping and Erecting a Complete 130-foot Railroad Span," Engineering Record 42.9 (1900): 196.

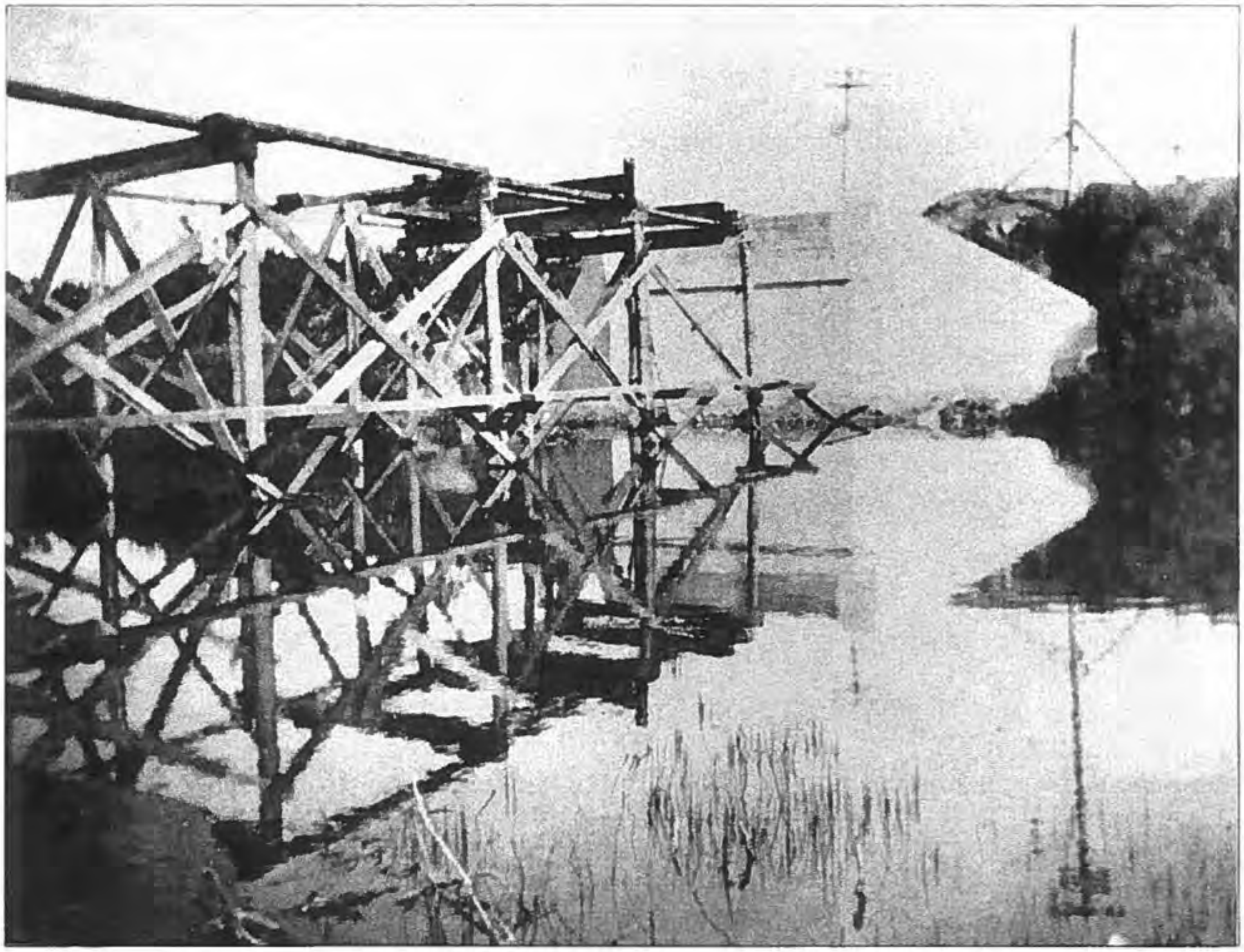

Figure 42: Falsework for truss with 100-foot span; Greenwood, Clark County, 1924; Elkhart Bridge Company. (Source: Willis E. Gifford, Jr.).

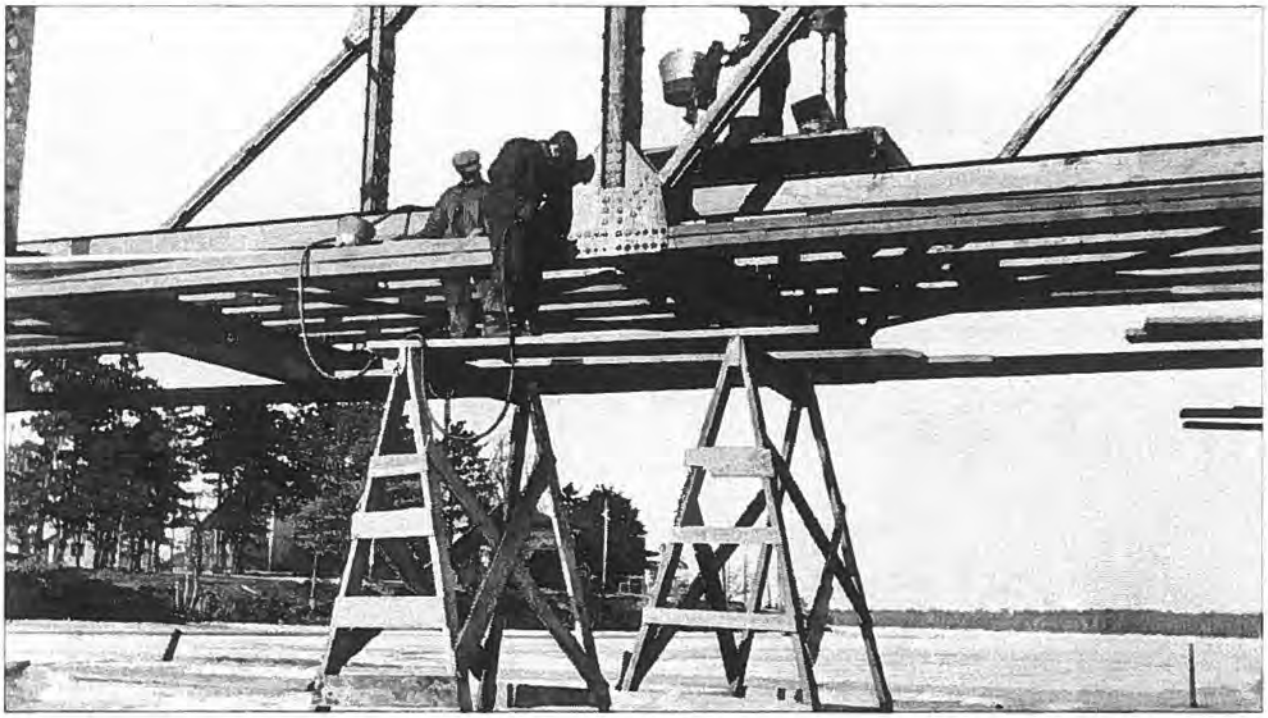

Figure 43: Using wood "horses" for falsework, Wausau Iron Works, c. 1920. (Source: State Historical Society of Wisconsin, Whi(X3)43962).

Figure 44: Transporting a bridge section to the site by horse and wagon. (Source: State Historical Society of Wisconsin, Whi(X3)43960).

Figure 45: Transporting a bridge section to the site by truck. (Source: State Historical Society of Wisconsin, WHi(X3)43959).

Used primarily on small jobs, the gin pole consisted of a single mast, equipped with a sheave (pulley wheel) at the top for cable lifting the load and with guy wires for moving the load in any direction (see Figure 46). A derrick generally comprised two inclined masts braced together and joined at the top, or a single mast with a movable boom or arm. For large projects, it was common to use a wheel-mounted frame known as a "traveler," which usually extended above the top chord of the bridge.[92] Field rigging tended to blur the distinctions between the different types of hoists, creating ingenious hybrids. When confronted with a derrick with two stiff legs, one experienced builder remarked, "[That's] a different kind of hoist altogether. Somebody was getting a little smart."[93] Although bridge builders constantly sought new ways to increase the efficiency, power, and mobility of their lifting mechanisms, some projects required "getting by" with less. Pile drivers were sometimes pressed into service to swing a truss into place (Figure 47).

For the most part, leading bridge companies were committed to using power tools and equipment whenever possible. Because of their relatively light weight and compact size, electric motors were particularly appealing, but, at the turn of the century, their use was generally restricted to urban areas with accessible power lines. In Wisconsin, most country bridges would have been beyond the reach of electric power lines until well into the 1930s. Therefore, steam boilers, gasoline engines, and old-fashioned horsepower were probably the dominant power-generating methods. Hand labor was also used—even to cut large beams in the field. One bridge builder of the 1920s and 1930s referred to it as "bull work."[94]

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[92] Skinner, 543-544; Fowler, "Machinery in Bridge Erection," 331; Waddell, The Designing of Ordinary Iron Highway Bridges, 209.

[93] Danko, interview with Krienke, Tape 2, Side 1, Part 1. A number of ingenious construction methods are recorded in "Shipping and Erecting a Complete 130-foot Railroad Span" 196; J.F. Jackson, "Floating a 300-foot Bridge Span into Position, Engineering News-Record 30 Aug. 1928: 310-11; "Ingenious Method Used to Float Bridge Spans to Site," Engineering News-Record 22 Nov. 1928: 764-65.

[94] Reference is to Emil Krienke who was a foreman for many years at Wausau Iron Works; Danko, interview with (continued...)

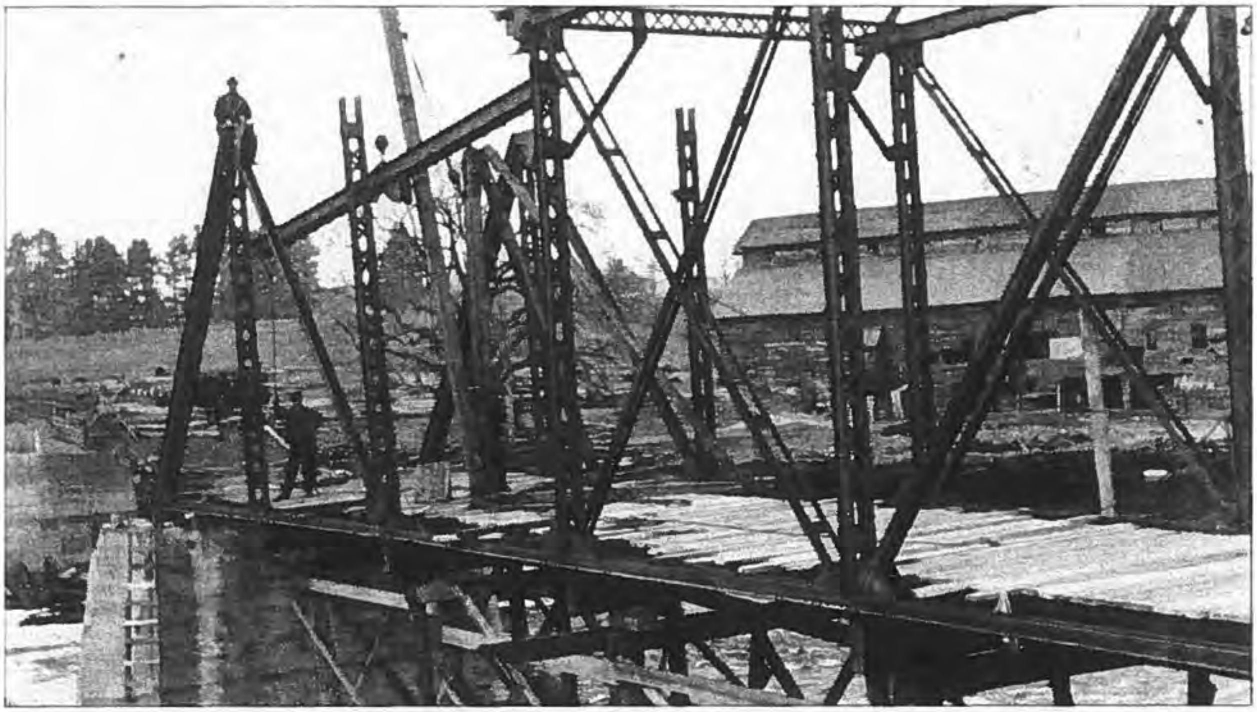

Figure 46: Lifting a top chord member into place by means of a gin pole. (Source: State Historical Society of Wisconsin, Whi(X3)43961).

[94](...continued)
Krienke, Tape 2, Side 1, Part 1.

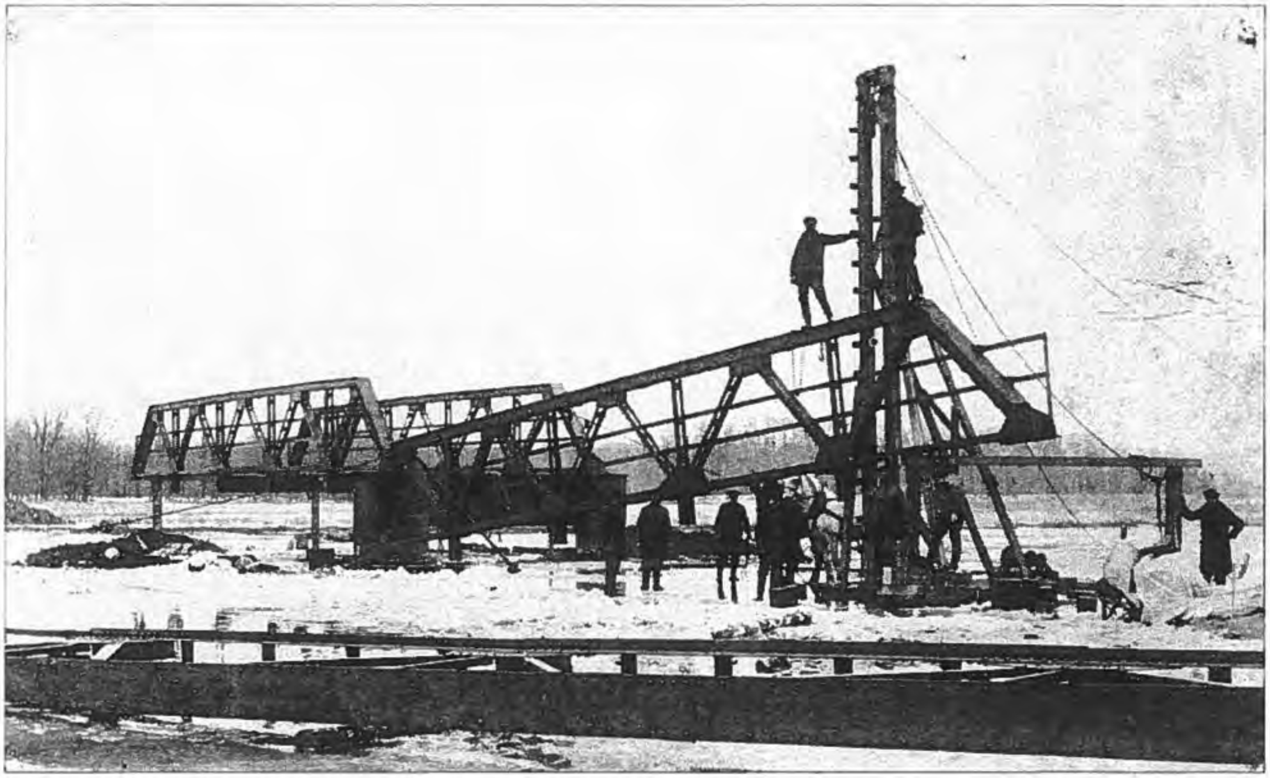

Figure 47: Using a horse and pile driver to lift an assembled, riveted Warren truss into place. (Source: State Historical Society of Wisconsin, WHi(X3)43965).

Field riveting was one operation that did not become truly practical and dependable until the advent of suitable power tools at the turn of the century. In the early stages of this process, the entire crew assisted in bolting the bridge sections together, precisely aligning the holes with tapered bolts, called "drift pins," and then inserting temporary fasteners, called "stitch bolts." Once the truss was in place, the workers assumed specialized roles in the riveting crew: heater, catcher, bucker, and driver. The heater man was expected to be able to throw a rivet, with accuracy, a distance of 30 or 40 feet to the catcher, who snared the hot bolt with a funnel-shaped bucket. After the rivet was inserted in the truss member (replacing the temporary stitch bolt), the bucker held the rivet head against the metal with a "bucking bar," while the driver flattened the other end of the shank with a power hammer, forming the permanent connection. The bucker was considered by some to be the most important member of the crew, since it was estimated that 90 percent of loose rivets resulted from "letting up" on the bucking bar (see Figure 48).[95]

Although the introduction of SHC standard plans in 1911 effectively terminated the role of bridge companies in designing metal-truss bridges in Wisconsin, bridge construction remained in private hands. Initially, the SHC focused on construction standards, exercising its authority in this area through a program of education and inspection. The SHC published bulletins on proper materials and techniques, and stringently reviewed all state-aided construction.[96] Eventually the agency also addressed the issue of qualifying contractors. Since "a great deal of trouble and general dissatisfaction" inevitably occurred when the lowest bidder was determined not to be qualified after

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[95] Danko, interview with Krienke, Tape 1, Side 1, Part 1; Tape 3, Side 1, Part 1.

[96] See for example, Wisconsin State Highway Commission, Instruction to County Highway Commissioners and Foremen for Building State Aid Roads, Bulletin No. 4 (Madison, Wis.: published by the State, 1914). Krienke discusses the importance and stringency of state inspection in Tape 2, Side 1, Part 2.

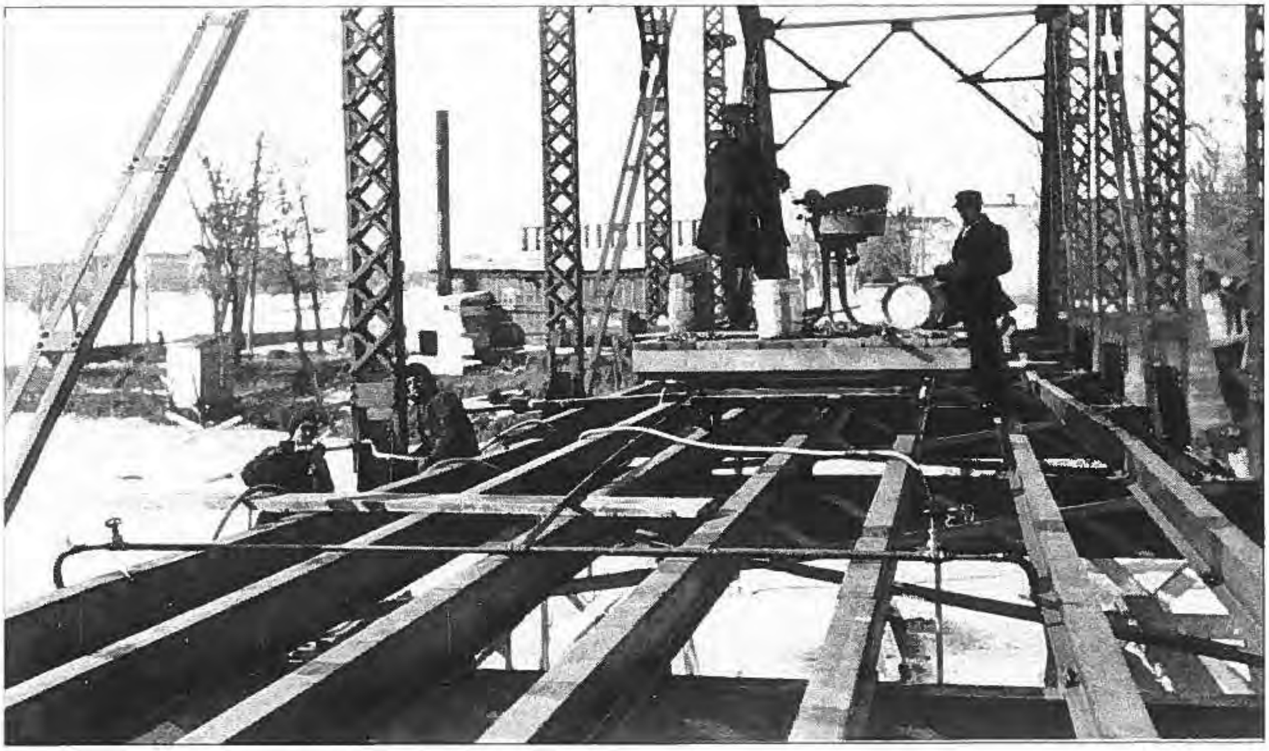

Figure 48: Field riveting a bridge. (Source: State Historical Society of Wisconsin, WHi(X3)43963).

the opening of the bids, the SHC in 1925 began screening contractors to ensure that all bidders were in fact capable of doing the work.[97]

[97] O. C. Rollman, "Classification of Contractors and Progress Rating" Badger Highways 4 (Feb.-Mar. 1928): 44-45+. According to Krienke (Tape 1, Side 1), initial qualification procedures favored the state's largest builders, prompting the SHC to revise its regulations in the mid-1930s so that smaller contractors could more successfully compete on bridge projects. Unfortunately, surviving records of the SHC provide minimal information on the agency's qualification practices. See Wisconsin State Highway Commission, Minutes, 6 Feb. 1931 (Collection of the Wisconsin Department of Transportation) 91-96; 15 Feb. 1932, 66; 12 Mar. 1932, 129-134.

CHAPTER 3

LAWS, LETTINGS, AND THE STATE HIGHWAY COMMISSION

Because the 1848 Wisconsin State Constitution prohibited state funding for transportation projects, the public relied on either private initiative or local governments to provide for highway bridges.[98] Private initiative generally took the form of joint-stock companies. These firms were chartered by the state to build, operate, and maintain a single bridge at a specific location; they should not be confused with the bridge-building companies of the late nineteenth century.[99] Private toll bridges were only profitable at heavily traveled crossings, leaving local governments solely responsible for bridging thousands of smaller crossings. Only gradually did the public come to realize that these spans were also worthy of first-class work.

The general responsibility and authority of local governments for bridge construction and maintenance was spelled out by the Wisconsin State Legislature in 1849 in seven provisions comprising about one page. This brief statement extended the restricted role of the government in public works projects. Although the 1849 law allowed county supervisors to assist towns in building or repairing bridges, it limited such spending to $1,000 per year for each town. By 1858, the law had been amended to increase the county's taxing authority for bridges, but this change did not portend a revolution. Strict conditions remained: a limit of $300 per bridge was specified, only one such tax was to be levied per year in each town, and unanimous approval by the county board was required.[100]

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[98] Ballard C. Campbell, "The Good Roads Movement in Wisconsin, 1890-1911" Wisconsin Magazine of History 49.4 (1966): 273.

[99] For a list of all bridge charters granted by the Wisconsin territorial and state legislatures, 1836-1921, see Davis, 218-222.

[100] "Of the Erection, Repairing and Preservation of Bridges," Chapter 16, Sec. 98, Revised Statutes of the State of Wisconsin (Southport, Wis., 1849); "An act to appoint Commissioners to lay out a state road...," Chapter 89, (continued...)

More expensive bridges could be built by special authority of the state legislature. In 1867, for example, the legislature authorized the town of Decatur in Green County to spend $1,250 for three bridges across the Sugar River. In the same year, it permitted the Wood County Board of Supervisors to collect $5,000 for each of three consecutive years to construct a bridge over the Wisconsin River.[101] Special legislation, however, was simply not an effective way to erect a significant number of highway bridges. Exceptions to the law proved particularly difficult to secure for less-traveled routes. Thus, most rural bridges were probably built within the strict funding limits of local governments. If the wood trestle construction of the Bark River Bridge is any indication, these bridges matched the quality of the roads, which were described by one traveller as "bottomless mud pits," and by another as "offering more adventure than ease."[102]

The story of the Good Roads Movement in Wisconsin, and its beneficial influence on highway travel, is a familiar one.[103] Preceding the Good Roads Movement by a decade or more, however, were changes in the county-aid bridge laws. Although these changes did not alter state aid for transportation projects, they did expand county aid for town bridges, and may have been an important precedent for later, more radical changes. In 1881, three significant amendments to the county-aid law were made. First, county aid was permitted, for construction or repair, if the cost of a bridge exceeded one-quarter of one percent of the assessed valuation of the town. Second, county

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[100](...continued)
Private and Local Laws, Legislature of Wisconsin, 1858, 157.

[101] "An act authorizing the town of Decatur, Green County, to build...three bridges...," Chapter 40, Private and Local Laws, 1867, State of Wisconsin, 60-61.

[102] Richard N. Current, The History of Wisconsin: Volume II, The Civil War Era, 1848-1873, ed. by William Fletcher Thompson (Madison, Wis.: State Historical Society of Wisconsin, 1976), 28; Robert Nesbit, Wisconsin: A History (Madison, Wis.: Univ. of Wisconsin Press, 1973), 197; Ballard C. Campbell, 273.

[103] Ballard C. Campbell, 273-293; Robert Nesbit, The History of Wisconsin: Volume III, Urbanization and Industrialization (Madison, Wis.: Univ. of Wisconsin Press, 1985), 139-147; Jeffrey A. Hess and Robert M. Frame III, Historic Highway Bridges in Wisconsin, Volume 1: An Historical Survey of Wisconsin Stone-Arch and Concrete-Arch Bridges (Madison, Wis.: Wisconsin Department of Transportation, 1986), 91-102 and 240-250.

aid was permitted if the county board determined that a bridge wholly within one town was necessary for the use and convenience of an adjoining town. Third, county participation in funding was linked to county participation in the letting, inspection, and acceptance of the bridge. These provisions seem to signal the beginning of public appreciation for a centralized system to provide an adequate highway network.[104]

In 1885, the state legislature raised the level of county participation to one-half the total cost of the bridge, but the change seems to have only modestly increased the number of county-aid bridge projects.[105] Although most people regarded bridges as a necessity, they continued to look upon substantial, well-constructed bridges as a luxury. Proponents of good bridges needed to convince the public that a bridge's long-term cost, including repair and maintenance, was the true measure of its expense, not the "first cost" of its construction. Wood trestle bridges were cheaper to build than metal trusses, but they deteriorated much more rapidly, and their multiple piers were far more vulnerable to floods. The Bark River Bridge, cited above, was erected for only $362.98, but it required repair the next year. In 1885, a town chairman urged the Manitowoc County Board of Supervisors not to replace a washed-out wood bridge with a structure of similar design, but rather to construct an iron bridge. "Let us build a bridge that will last a lifetime," he pleaded, "and not have any further trouble."[106]

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[104] "An act entitled to amend...relating to erecting and repairing bridges," Chapter 315, Laws of Wisconsin, 1881 407-408. The town also was required to raise its share of the expense before requesting county assistance.

[105] "An act to amend chapter 315...relating to erecting and repairing bridges," Chapter 187, Laws of Wisconsin, 1885, 162-164. A sampling of available county board records suggests that county-aid bridge projects were infrequent during the 1880s, and numbered five to ten per county per year during the 1890s.

[106] Hannah Swart, Koshkonong Country Revisited: An Anthology (Fort Atkinson, Wis.: Fort Atkinson Historical Society, 1983), 250-251; Manitowoc County, Wisconsin, Manitowoc County Board of Supervisors, Proceedings, 1885, 4. Manitowoc did decide on an iron bridge, which lasted almost 100 years before traffic volumes and its narrow width required its replacement.

Even when county and town officials were willing to increase their budgets for bridge construction, they rarely had at their disposal the technical expertise to make a proper selection of bridge design. As one knowledgeable observer remarked in 1890, "Competent practicing engineers, fitted to give this advice, are not to be found outside of the large cities and to employ them is so expensive as to be a large item in the cost of an ordinary bridge."[107] But as competition grew more intense in the early 1900s, and numerous small contractors began bidding on projects, highway reformers became more and more convinced that "the governing considerations" were "those of salesmanship and not of engineering."[108] By way of illustration, the reformers were fond of publishing photographs of flimsy rural bridges that had collapsed under the demands of modern traffic (see Figure 49). In Wisconsin, as elsewhere in the country, the advocates of good roads urged a typical remedy of the Progressive Era—standardization and professionalization under the auspices of a centralized authority.

In 1907, the state legislature established a Highway Division within the Wisconsin Geological and Natural History Survey to conduct experiments in road design and to advise local governments about specific projects. Town governments, traditionally reluctant to hire an independent engineer to assist in bridge building, could now avail themselves of free engineering counsel from the state. At the same time, the legislature required counties to make a commitment to professional oversight and increased funding by appointing "a competent engineer or experienced road builder" to serve as County Highway Commissioner and by levying a tax of not less than one-fourth mill nor more than two mills on the assessed valuation of all county property for the county road and bridge fund.[109]

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[107] Boller, 91.

[108] Wisconsin State Highway Commission, Fifth Biennial Report, 1922-1924 (Madison, Wis.: published by the State, 1925), 70-71.

[109] Ballard C. Campbell, 278-279; "An act to add subsections...relating to the improvement of roads and bridges by counties," Chapter 552, Laws of Wisconsin, 1907, 1171-72.

Figure 49: This photograph appeared in an early publication of the Wisconsin Highway Division. Noting that the structure had "failed under a load that should be safe on any bridge built hereafter in the state," the original caption asked the reader to compare "the light flimsy trusses" with bridge "built on plans of the Highway Division." (Source: W.O. Hotchkiss, First Biennial Report of the Highway Division [Madison, 1909], p. 39).

In 1908, Wisconsin voters removed the greatest obstacle to creating a progressive statewide system of bridge and highway construction. In that year, by a three-to-one margin, they eliminated the state's constitutional prohibition against direct state aid to transportation projects. When the legislature made its first appropriation for highway improvements in 1911, it also transformed the Highway Division of the Geological Survey into an autonomous SHC, which was charged with overseeing the expenditure of state funds to develop a state highway network.[110] Like the former Highway Division, the SHC emphasized the use of standardized plans for various types of bridges and culverts.[111] The first set of standardized truss plans encompassed spans ranging from 36 to 128 feet, generally in 5-foot increments. All but one had a 16-foot roadway. Revised several times by the 1920s, these plans continually incorporated the latest engineering wisdom concerning span width, length, and detailing.

In the first 3½ years of its work, the SHC designed over 1,500 bridges. All were designed to carry a 15-ton live load. Believing firmly in the use of reinforced concrete to "the fullest extent practical," the SHC was pleased that all but three had concrete floors. These figures included almost 900 bridges requested by local governments in 70 counties. Practically all the local bridges in the state during these years were either designed by the SHC or were based on SHC standard plans.[112]

Despite its enthusiastic support for concrete construction, the SHC declared in 1926 that the steel bridge "is not looked upon with disfavor" and continued to refine its truss designs. In the late 1930s, the SHC made a major commitment to keeping its standardized plans up to date by dropping the Pratt design in favor of the Warren for overhead trusses. Newly completed SHC-designed truss

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[110] Ballard C. Campbell, 279-284; Davis, 104.

[111] Wisconsin State Highway Commission, Second Biennial Report, 24.

[112] Davis, 112-113; Wisconsin State Highway Commission, Second Biennial Report 21, 14, 30; see also Wisconsin State Highway Commission, Preliminary Biennial Report...1911 to 1913 (Madison, Wis.: published by the State, 1913), 17.

bridges, both monumental and modest, also continued to be featured in the photographic sections of the agency's biennial reports. The metal-truss bridge remained cost effective in many situations; the SHC used a few designs even after World War II. Nevertheless, the SHC clearly favored concrete spans, citing advantages of lower cost, greater compatibility with aesthetic treatment, and greater adaptability to remodeling, especially in terms of roadway widening.[113]

During its early years, the SHC was guided by five key figures, all of whom had previously worked at the Highway Division of the Geological Survey: W.O. Hotchkiss, first chief of the Highway Division; Arthur R. Hirst, first state highway engineer; Martin W. Torkelson, first state bridge engineer; Herbert C. Kuelling, assistant highway engineer; and Walter C. Buetow, assistant bridge engineer. When these men moved on to the SHC, they found a helpful ally in Frederick E. Turneaure, an engineering professor at the University of Wisconsin who had been instrumental in establishing the new state highway agency. Brief biographies of the six individuals who played key roles in the development of Wisconsin's highway system follow.

William Otis Hotchkiss (1878-1954)

Born in Eau Claire, Wisconsin, Hotchkiss received his undergraduate degree in 1903 from the University of Wisconsin, which also awarded him a degree in civil engineering in 1908 and a Ph.D. in 1916. From 1904 to 1907, he taught geology and petrology at his alma mater. In 1906, he joined the Wisconsin Geological and Natural History Survey and became the first head of the agency's Highway Division. Called "the man who started the good roads movement in Wisconsin," Hotchkiss helped draft the law that set up the SHC and was an effective lobbyist for the state-aid highway

[113] The SHC succinctly assessed the pros and cons of steel and concrete bridges; see Wisconsin State Highway Commission, Sixth Biennial Report, 1925-1926 (Madison, Wis.: published by the State, 1926), 67. From 1911 to 1915, truss bridges in Wisconsin cost considerably less per foot than concrete structures, but then steel began its "great advance in price"; see Wisconsin State Highway Commission, Fourth Biennial Report, 1916-1918 (Madison, Wis.: published by the State, 1918), 11-12.

program before the legislature. He served on the SHC from 1911 to 1925, when he resigned to accept the presidency of the Michigan College of Mines at Houghton, Michigan. Despite his fame for highway work, Hotchkiss's chief interest was geology. Appointed State Geologist in 1909, he wrote numerous works on physical geography, served on the War Minerals Committee during World War I, and initiated several important studies of Wisconsin's mineral resources, including SHC surveys of road materials.[114]

Arthur Roscoe Hirst (1881-1932)

A New Yorker by birth, Hirst earned his engineering degree from the University of Maryland. Following employment with the Pennsylvania Railroad, he entered the field of highway engineering, accepting a position with the Maryland Highway Department and later with the Illinois state highway agency. Hirst was in Illinois for only a short time when Wisconsin set up its Highway Division under the Geological Survey in 1907. He became the Division's first state highway engineer, continuing in that capacity with the SHC until 1924. In that year, Hirst resigned to run, unsuccessfully, for governor. Subsequently, he worked as a consulting engineer and spent the last three years of his life in an administrative position with the U.S. Bureau of Public Roads. He was been credited with "two of the most important advances ever made in highway development, namely the first adequate highway patrol system in the West, and the invention and successful installation of the number system of marking highways."[115]

[114] Dictionary of Wisconsin Biography (Madison, Wis.: State Historical Society of Wisconsin, 1960), 178; "William Otis Hotchkiss," Badger Highways 1.10 (1925): 1+.

[115] M.W. Torkelson, "Arthur Roscoe Hirst," in Wisconsin State Highway Commission, Ninth Biennial Report (Madison, Wis.: published by the State, 1932), 9-11.

Martin Wilhelm Torkelson (1878-1963)

The son of a Civil War veteran, Torkelson was born in Jackson County, Wisconsin. He received engineering degrees from the University of Wisconsin in 1904 and 1916. After four years of employment with railroads in Kentucky, Tennessee, and Virginia, he joined the Highway Division of the Wisconsin Geological Survey in 1908 as state bridge engineer. He performed the same duties with the SHC until 1921, when he became assistant state highway engineer. In 1925, Torkelson resigned from the SHC in protest against what he considered to be the growing influence of private contractors. Four years later, however, he returned as director of regional planning, a position he held until 1955. He was also state highway engineer from 1931 to 1956, executive office of the Wisconsin State Planning Board from 1932 to 1956, and Works Progress Administrator for Wisconsin from 1936 to 1938. As a colleague noted in 1925, "the credit for putting the construction of bridges on an honest, sound business basis, and the improvements of design and finish, is due to Mr. Torkelson's untiring efforts."[116]

Herbert J. Kuelling (dates not available)

Born in Shullsburg, Wisconsin, Kuelling received his undergraduate degree from the University of Wisconsin in 1908, and went to work for the newly created Highway Division of the Wisconsin Geological Survey as an assistant in the road and bridge departments. After earning a degree in civil engineering from the University of Wisconsin in 1911, he took a leave of absence from the SHC and organized a highway department for Milwaukee County, pioneering a program of concrete highway construction. He returned to Madison and the SHC in 1917, taking over the position of design engineer. Although he left the agency in 1925 to become a consulting engineer in

[116] Who's Who in America (Chicago: Marquis Who's Who, 1940), 2531; Who Was Who in American History--Science and Technology (Chicago: Marquis Who's Who, c. 1976), 609. The quotation is from F.M. Balsey, "Beginning of Road Building in Wisconsin," Roads and Streets 63.4 (1925): 674.

Milwaukee, he returned two years later as state highway engineer, prompting the resignation of Martin W. Torkelson, who believed that Kuelling was too closely associated with private contractors, particularly the Vibrolithic (Paving) Company. Although a legislative committee found no substance to any charges of impropriety, Kuelling resigned from the SHC just over a year later, taking an executive position with the Wisconsin Associated Contractors.[117]

Walter C. Buetow (1886 - death date not available)

Buetow was born in Milwaukee in 1886 and received a degree in engineering from the University of Wisconsin in 1908. He was an instructor at the university and a member of the Highway Division in the Wisconsin Geological Survey. In 1911, he joined the bridge department of the SHC, but soon moved to become a division engineer, first with the La Crosse Division, and later with the Madison Division. In the early 1920s, Buetow was appointed state bridge engineer. He resigned from the SHC in 1924 to join the Stein Construction Company of Milwaukee, a bridge construction and engineering firm. In 1928, he rejoined the SHC as state highway engineer, replacing H.J. Kuelling, who had been criticized, both inside and outside the agency, for his previous associations with private contractors. In announcing Buetow's appointment, the SHC stated that Buetow was returning to the agency "with no previous entangling alliances, a new man in the position and perfectly free to work out his own policies unaffected by anyone." Buetow remained state highway engineer through 1930.[118]

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[117] "H.J. Kuelling Good-Bye and Good Luck," Badger Highways 1.8 (1925): 3; "The Road School and Other Things," Badger Highways 2.2 (1927): 1-2; "State Highway Commission Reorganization" Badger Highways 3.3-4 (1927): 1+; and "Highway Probe Committee Report," Badger Highways 3.3-4 (1927): 3.

[118] "Major Changes Occur in State Highway Department" Badger Highways 4.5 (1928): 2-3; see the list of employees in Wisconsin State Highway Commission, Eighth Biennial Report (Madison, Wis.: published by the State, 1930), n.p.

Frederick Eugene Turneaure (1866-1955)

Born on a farm near Freeport, Illinois, Turneaure received his degree in engineering from Cornell University in 1889 and taught at Washington University in St. Louis before joining the University of Wisconsin as a professor of bridge and hydraulic engineering. Appointed dean of the engineering school in 1902, he became dean of the College of Mechanics and Engineering two years later, remaining in that position until his retirement in 1937. Widely known as an authority on bridge construction and structural engineering, Turneaure authored and collaborated on several engineering texts, including the influential Modern Frame Structures (1905). He was an ex officio member of the SHC from its founding in 1911 until 1930.[119]

[119] Dictionary of Wisconsin Biography, 353; "Dean Turneaure Makes Statement," Badger Highways 3.2 (1927): 2; "Governor Kohler Appoints Members of New Highway Commission," Badger Highways 5.7 (1929): 4-5.

CHAPTER 4

BRIDGE-BUILDING COMPANIES

More than 100 people and companies in Wisconsin have claimed, at one time or another, to be "bridge builders."[120] This large group had a variety of relationships with the bridge building process. At one extreme were a few, large, well-capitalized, well-equipped companies capable of handling all aspects of bridge design, fabrication, and erection. At the other extreme were individual entrepreneurs or craftsmen, such as blacksmiths and carpenters, who attempted a few, small, local projects, erecting prefabricated trusses ordered from a major manufacturer.

Most bridge-building operations were ephemeral: only 24 are known to have survived for more than ten years. Of the longer-lived bridge builders, two groups are worth describing in some detail. First, there are the major fabricating and erecting companies that stayed in business for 20 years or more: Milwaukee Bridge and Iron Works, 1870-1906; Milwaukee Bridge Company, 1904-1961; Wausau Iron Works, 1907-1951; Wisconsin Bridge and Iron Company, 1887-1983; and Worden-Allen Company, 1905-c. 1967. Second, there are those individuals and companies that appear to have found a niche for themselves among the giants. This group includes Willis E. Gifford, an agent for Elkhart Bridge and Iron Company of Elkhart, Indiana, 1916-1931; Ernst Kunert Manufacturing Company (later Dornfield-Kunert) of Watertown, Wisconsin, 1893-1914; and the La Crosse Bridge and Steel Company, 1899-1915. Below, in alphabetical order, are brief descriptions of these various operations.

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[120] For a list of Wisconsin bridge builders from 1872 to 1928, see Danko, "The Development of the Truss Bridge," 62-68. Excluded from our analysis are promotional companies interested in only one bridge, such as the Prescott Bridge Company, which was organized in 1920 to build a toll bridge across the St. Croix River at Prescott, Wisconsin. These companies financed the construction and operation of a single bridge at a single location.

Willis E. Gifford

Born in New York in 1867, Gifford resided in Michigan before moving to Madison, Wisconsin, in 1900. Initially, he traveled the state selling road graders and other machinery. As late as 1916, Gifford identified himself in city directories simply as a "traveling salesman." As early as 1905, however, he earned at least part of his livelihood as a bridge contracting agent of the Elkhart Bridge and Iron Company of Elkhart, Indiana. He continued his association with the company until 1931 (see Figure 50).[121]

Elkhart Bridge and Iron Company was established in 1904 to take over the existing plant and business of the Elkhart Bridge Company, a failing concern founded three years earlier. Frank Brumbaugh and John Fieldhouse were the prime movers behind both companies. Brumbaugh had been an agent for the Bellefontaine Bridge Company of Ohio, and Fieldhouse was an Elkhart industrialist who wanted to boost the local economy. By 1910, the reorganized operation boasted 125 employees "who fabricated 4,000 tons of steel and earned $40,000 annually." In fabricating its metal trusses, Elkhart followed the pattern of shop erection and disassembly before shipment to the field site. The company took pride in the ornamental features of its bridges, although the firm's remaining Wisconsin examples do not display much ornamentation.[122]

Little is known about Gifford's mode of operation and the exact details of his relationship with Elkhart Bridge and Iron. According to his son, he was never involved with the actual

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[121] This section relies heavily on author's interview with Gifford's son, Willis E. Gifford, Jr., October 5, 1987. Gifford Jr. has in his possession a photograph album documenting his father's bridge projects with labeled photographs and typewritten lists. The list for 1905 begins with the number 82, indicating that several projects had been completed before that date. The album also contains a newspaper article, dated 1909, that identifies Gifford as an agent for Elkhart Bridge and Iron Company. Additional information on Gifford's occupations was gleaned from Mss. Census, 1900, Enumeration District 47, sheet 1, line 62; Mss. Census, 1910, Enumeration District 64, sheet 6, line 94, in State Historical Society of Wisconsin; Madison City Directory, 1902 172; 1904 135; 1907 144; 1909 157; 1911 179; 1914 187; 1916 184, 627; Wright's Madison City Directory, 1931 326.

[122] For a brief history of Elkhart Bridge and Iron Company, see James L. Cooper, Iron Monuments to Distant Posterity: Indiana's Metal Bridges, 1870-1930 (Sponsored by DePauw University, Indiana, 1987) 29-30.

Figure 50: Letterhead of the Willis E. Gifford Company, general agent of the Elkhart Bridge & Iron Company, 1923. (Source: Bridge Section files, WisDOT).

construction of a bridge. Rather, he attended lettings and arranged for the contract. After securing a project, he contacted the company and hired a foreman, who took charge of the actual erection. Most of Gifford's early bridges were pony trusses, either pin-connected Pratts or riveted Warrens. The longest bridge he contracted for was a 150-foot, Pratt overhead truss, although he arranged for repair work on larger structures. Apparently, he also built I-beam and concrete-girder spans, although it is unknown if Elkhart Bridge and Iron was involved with these projects. Before World War I, Gifford built as many as 70 bridges in one year, but the number declined drastically in the 1920s. Elkhart Bridge and Iron survived at least the early years of the Depression. Gifford, however, built only one bridge in 1929, and that may have been his last. He died in Madison in the 1940s.

Ernst Kunert Manufacturing Company

Founded in Watertown, Wisconsin, in 1883, this firm operated under the name of Ernst Kunert Manufacturing Company for the next twenty years. In 1903, however, it added J. F. Dornfeld of Chicago to the board of directors and changed its name to the Dornfeld-Kunert Company. The initial plant consisted of a brass and iron foundry, a steam boiler shop, and a machine shop capable of manufacturing "machinery of every kind." By 1893, the company was also advertising itself as a manufacturer of metal-truss bridges, and it continued to do so until 1910 (see Figure 51).

In 1915, the company entered bankruptcy.[123] Throughout its history, the Ernst Kunert Manufacturing Company struggled to compete with the large bridge companies based in Milwaukee and the neighboring Central States Bridge Company. An early example of the company's bridge work, the Sock Road Bridge in Dodge County, shows a crude metal-working capacity. Many components

[123] This discussion is based primarily on "The Sock Road Bridge," Historic American Engineering Record Report, HAER No. WI-2. See also Danko, "Selective Survey" 19; Wright's Watertown Directory, 1887, 1893; Wisconsin State Gazetteer and Business Directory, 1897-1927; Elmer C. Kiessling, Watertown Remembered (Milwaukee: Watertown Historical Society, 1976).

Figure 51: Advertisement of the Ernest Kunert Manufacturing Company, 1902. (Source: Young & Co.'s Business and Professional Directory of Milwaukee, 1902).

of this 1893 bridge appear to have been cut to shape manually rather than formed by machine. The pedestals employ irregularly cut plates, and the lacing bars, although of uniform width, exhibit uneven trimming. Slots and openings to accommodate the counters in the intermediate post channels, which normally were punched by machine, were outlined with a drill and knocked out by hand. These examples suggest that the company was perhaps too poorly capitalized to make use of the more efficient slotting and punching machinery customarily employed by larger bridge fabrication firms. Kunert's inability to make the transition to a more sophisticated shop may have led to its demise.

La Crosse Bridge and Steel Company

This company was begun by Charles M. Horton in 1899, and incorporated the following year as the Horton Bridge and Steel Company, with a capital stock of $25,000. Horton was born in New York in 1850. He had come to Duluth, Minnesota, as early as 1894, and by 1897 was working there as a manufacturer's agent. In 1898, he moved to Superior, Wisconsin, and in 1899 to La Crosse.[124]

J.F. McDonough and John A. Elliott were the other partners with Horton. Stockholders included William Torrance, partner in a local steel foundry, and the W.J. Solberg & Son Company, a local boiler manufacturer. Horton Bridge and Steel was organized to manufacture and sell iron, steel, and other bridge materials, as well as to manufacture, erect, and construct all types of iron and steel buildings. By using Horton's patented designs, the company hoped to build bridges lighter, cheaper, and stronger than its competitors.

Horton's first patent, issued in 1897, related to bridge trusses, trussed beams, and supporting columns or posts that virtually eliminated the use of rivets. According to Horton, rivets needlessly weakened bridge connections by perforating the metal. As an alternative, Horton advocated the use

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[124] This treatment of La Crosse Bridge and Steel Company closely follows Diane Kromm, "McGilvray Road Bridges Nos. 1-5 (Van Loon Wildlife Area Bridges)," Historic American Engineering Record Report, HAER No. WI-22, 1987.

of such devices as sleeves, hangers, hook-clips, and socket-supports to secure metal components. In addition, he recommended that bridge members be designed as simply as possible to facilitate rapid assembly without the use of expensive machinery and specialized labor. Horton claimed that his design produced a strong, durable, and light structure at a relatively low cost. He illustrated his patent with an arch truss bridge. The best remaining examples of this design are the McGilvray Road Bridges in La Crosse County.[125]

In 1898, Horton submitted three more patent applications. Two of the patents were issued in 1898 and related to metal beams that eliminated rivets and bolts. Patent No. 608,861 consisted of a metal box-beam in which the flanges extended from the plates, forming a channel that secured the beams. Patent No. 611,202 followed the same principle using a metal I-beam. In 1899, Horton received his second patent for a bridge design (No. 621,672). This patent was for a Pratt through truss bridge which, like his previous inventions, limited the number of joints that punctured the metal. The top chord incorporated his idea for securing the parts of a box-beam without rivets or bolts, instead using clips with flange or rib extensions. No evidence has been found that the La Crosse Bridge and Steel Company ever erected a bridge using this design.

Stockholder W.J. Solberg's boilermaking firm agreed to furnish the new company with a building on its property. By the end of June 1900, the plant was nearly finished and the machinery about to be installed. The arrival of a large punch being manufactured in the east was delayed because of a strike. By mid-August the building was almost ready for occupancy. In the meantime, the company continued to fulfill bridge contracts.

[125] A photograph showing a bowstring arch with hanger attachments was located in the WisDOT Bridge Section. On the back is written, "May 10, 1934. Bowstring Truss. Just south of Desoto on State Highway 35. Showing supports under floor beams and condition of truss." Desoto is about 40 miles south of McGilvray Road.

One year after the company incorporated, it reorganized. Charles M. Horton left the company, selling his manufacturing rights and agreeing to receive royalty payments from the firm.[126] On April 16, 1901, the company stockholders met and changed the name of the firm to the La Crosse Bridge and Steel Company. William Torrance became company president and manager. The company showed a profit for the previous year and the stockholders contemplated building a new factory. William Torrance became mayor of La Crosse in 1903, and soon afterwards, J.F. McDonough assumed the position of president and director. Early on, the company acquired a license to transact business in Minnesota as well as Wisconsin. The capital stock remained at $25,000 until the company ceased operations in 1915.

Milwaukee Bridge and Iron Works

This company was "the outcome of a small private business established in 1870" by Leon Soulerin and Garth W. James.[127] Little is known about either man, although Soulerin patented an unusual drawbridge in 1874.[128] In 1872, Milwaukee Bridge and Iron built a railroad bridge over the White River in northern Wisconsin with an impressive span of 1,600 feet.[129] Soulerin dropped out of the company in 1876, followed by James a year later. In 1877, the firm was controlled by F. S. Ilsley, who apparently departed after a single year. During this period, an advertisement announced that the

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[126] According to Kromm ("McGilvray Road Bridges No. 1-5," Historic American Engineering Record, HAER No. WI-22, 1987), Horton continued to bid on bridge projects in the La Crosse area for a short time after leaving the company.

[127] Milwaukee Sentinel, "Illustrated Description of Milwaukee," Illustrated Annual Review: Milwaukee Trades and Industries (Milwaukee, 1889) 149.

[128] The bridge was a "lowering bridge," which submerged the deck under water; see Patent No. 153,729. No record has been found that a bridge based on this patent was ever built.

[129] Roy L. Martin, History of the Wisconsin Central (Boston: Railway and Locomotive Historical Society, 1941), photograph caption facing p. 30. The bridge appears to be an iron trestle, with mid-panel bracing reminiscent of the Fink truss design.

company built "Wrought Iron Railway and Highway Bridges," and showed a substantial Parker truss located on the Baltimore and Ohio Railroad in South Chicago, Illinois. Despite his short tenure, Ilsley was praised as a successful bridge builder. Under his ownership, the company completed bridges in Darlington, Racine, Stevens Point, and Theresa, Wisconsin, and in Mississippi and Iowa.[130]

In 1878, William H. Keepers, who had joined the firm in 1874, purchased a partnership. A native of Ohio, Keepers had been engaged in bridge building since 1866. His first partner was James H. Cunningham, a recent Scottish immigrant who had joined Milwaukee Bridge and Iron in 1876 as an engineer. Cunningham was a member of both the Liverpool and American societies of civil engineers. In 1881, the company had a capacity of 1,800 tons per year and was involved in "iron work for bridges of all kinds, piers, trestles, roofs, turntables and general iron construction."[131]

In 1882, Cunningham retired and was replaced by Augustus T. Riddel, the former owner of a steam bakery.[132] In 1887, the company filed papers of incorporation, with a capital stock of $125,000.[133] In 1889, the firm employed "200 men in the shops, and from seven to ten gangs of from five to seventy-five men each" for the erecting. L.E. Sangdahl, a civil engineer, directed ten draftsmen "in making shop drawings and designs for new work." The firm grossed over $800,000 in 1889 on projects in all the contiguous states and in Texas, Nebraska, and Colorado. One of these bridges, the Belle Isle Bridge in Detroit, Michigan, had 11 Pratt overhead spans of 156 feet each and a 318-foot draw span. The cost of this bridge was $300,000. The company also built the impressive Menomonee River Valley viaduct in Milwaukee, which was 2,085 feet long and cost $75,000.

[130] Milwaukee Sentinel 9 November 1877, 3 December 1877; Lola Bennett, "White River Bridge," Historic American Engineering Record Report, HAER No. WI-16, 1987. Ilsley, who was presumably related to the prominent Milwaukee banking family, had signed Soulerin's 1874 bridge patent as a witness; see Patent No. 153,729.

[131] Frank A. Flower, History of Milwaukee, Wisconsin (Chicago: Western Historical Co., 1881) 1295.

[132] Hogg's Milwaukee City Directory, 1878 409, 539. Oconomowoc File, Letterhead correspondence, January 16, 1882, in response to bridge letting for Walnut Street to Oakwood Street Bridge.

[133] Milwaukee Sentinel 9 April 1887.

Confident of future expansion, the company purchased an additional six acres of land in Milwaukee to "be built upon to furnish more shop and factory room."[134]

By 1892, Julius G. Wagner, a longtime Milwaukee iron manufacturer, had taken over as "proprietor."[135] At the same time, Wagner maintained his firm of Architectural Iron Works. In 1897, he may have consolidated both into the Julius G. Wagner Company.[136] Riddell went on to the Milwaukee Variety Iron Works, and Keepers joined James H. Wynkoop in a consulting and contracting engineering firm.[137] Wagner remained in control of Milwaukee Bridge and Iron until 1901, when it joined with 24 other companies to form the American Bridge Company.[138] For a few years, it retained its original name in advertising. The City Directory for 1905-1906 is the last one in which Milwaukee Bridge and Iron Works is listed.[139]

Milwaukee Bridge Company

Originally organized in 1902 as Milwaukee Steel Structural Company, the firm changed its name in 1903 to Milwaukee Bridge Company. In that year, the company received its first major contract for the design and construction of a simple trunnion bascule bridge in Milwaukee. The first officers were C. H. Starke, president; Conrad Trimborn, vice-president and treasurer; Max W. Nohl,

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[134] "Illustrated Description" 54, 149; Milwaukee Sentinel 15 January 1890.

[135] As early as 1871, Wagner was a partner with John Hornbach in the firm, Hornbach and Wagner, an "iron works" which made "iron doors, railing, etc"; see Milwaukee City Directory, 1871-1872 301, 345.

[136] Keepers and Riddell owned the company through 1890; Wright's Directory of Milwaukee for 1890 584. On Wagner, see Wright's Directory of Milwaukee for 1892 946, 1040; 1897 965, 1066. The Wisconsin State Gazetteer and Business Directory, 1891-1892 does not list Milwaukee Bridge and Iron.

[137] Wright's Directory of Milwaukee for 1891 459, 996; 1892 474, 762.

[138] A short description of the merger is in Cooper 32-39.

[139] Wright's Directory of Milwaukee for 1905 1362.

Secretary, and F.W. Moore, engineer.[140]

Christopher H. Starke was long active in a number of firms involved in construction and tugboats since 1869. He was a laborer in 1865, a piledriver by 1870, and a dredger and piledriver by 1871.[141] He joined with Henry and Conrad Starke in the firm of Conro and Starke Co., dredgers. Conro and Starke was a successor to Hasbrouch and Conro, contractors, who also had a tugboat operation. By 1878, Christopher, Conrad, Henry, and Fritz, along with W. H. Meyer, formed Starke Bros. and Co., proprietors of Milwaukee Tugboat Line. By 1882, the company had evolved into Starke, Smith and Co., and by 1899, C.H. Starke Dredge and Dock Co. Christopher Starke was not, however, listed as an officer of this latter company. Instead, he was by this time president of Milwaukee Tugboat Line.[142] He appears to have remained president of both Milwaukee Tugboat Line and Milwaukee Bridge Company until 1914.[143]

In 1886, Conrad Trimborn was a clerk in an unnamed business. Two years later, with his brothers Joseph A., August W., and Peter W., he had established Trimborn Brothers, selling building materials, wood, and coal. By 1890, Trimborn Brothers was just August and Conrad, who, by 1892, had added the manufacture of lime and selling of cement to their business. In 1894, Conrad Trimborn joined C.H. Starke and Co., and, in 1903, he became vice-president and treasurer of Milwaukee Bridge Company. He became president in 1915. Trimborn remained president and secretary of

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140 Wright's Directory of Milwaukee for 1903 44; Articles of Incorporation of Milwaukee Steel Structural Company, 2 September 1902; Amendment to Articles of Incorporation, changing the firm's name to Milwaukee Bridge Company, 25 February 1903, in Volume Q 348, 601, Incorporation Papers, Milwaukee County Historical Society. The bascule project was completed in 1904 at Muskego Avenue over the Menomonee River; see Jeffrey A. Hess and Robert M. Frame III, "Bascule Bridge Intensive Survey Form for Muskego Avenue Bascule Bridge (P-40-610)," Wisconsin Department of Transportation, 1986.

141 Milwaukee City Directory, 1865 262; 1869-1870 294; 1870-1871 270; 1871-1872 281.

142 The Milwaukee Directory for 1878 469; 1882 561; Wright's Directory of Milwaukee for 1892 742, 878; 1894 963; 1899 934.

143 Wright's Directory of Milwaukee for 1902 1056; 1903 1108; 1904 1168; 1905 1197; 1906 1258; 1907 1367; 1909 1426; 1911 1515; 1913 1571.

Milwaukee Bridge Company into the 1930s, and several other Trimborns were also employed there. In 1961, a third generation of Trimborns was in charge of the company.[144]

In 1891, F.W. Moore was a draftsman with Keepers and Wynkoop, and in 1892, he was a civil engineer, possibly with Wisconsin Bridge and Iron Company.[145] He then worked for Milwaukee Variety Iron Works and Milwaukee Bridge and Iron Works. In 1899, he became engineer for J. G. Wagner Company. At the time Wagner was also proprietor of Milwaukee Bridge and Iron Works. Moore joined Milwaukee Bridge Company in 1903, and was listed as chief engineer in 1904 and 1905. He remained with this company at least through 1913.[146]

Wausau Iron Works

This company was started in 1907 as a branch of Northern Boiler and Iron Works of Appleton, Wisconsin. In 1908, two brothers, Tony and John Heinzen of Manitowoc, took over the facilities. They joined Fred W. Krause of Wausau and incorporated as the Wausau Iron Works, with the manufacture of boilers as the principal business.[147] In 1910, the company entered the field of bridge fabricating and erecting, and was able to compete successfully with the large Milwaukee firms.

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[144] Wright's Directory of Milwaukee for 1886 748; 1888 789; 1890 929; 1893 993; 1894 1015; 1895 945; 1899 985; 1903 1171; 1927 1886; 1932 1596; 1938 792; 1950 823; 1961 1058; Wisconsin State Gazetteer and Business Directory, 1915-1916 803.

[145] Wright's Directory of Milwaukee for 1891 623; 1892 648. No company affiliation is given for Moore in 1892. The name "Moore," however, appears on plans for the Hewitt Street Bridge constructed by the Wisconsin Bridge and Iron Company in Neillsville, Clark County in 1892.

[146] Wright's Directory of Milwaukee for 1893 691; 1894 705; 1895 659; 1899 687; 1900 732; 1901 724; 1902, not listed; 1903 810; 1904 858; 1905 878, 1906 921; 1907 998; 1909 1042; 1911 1102; 1913 1141. Fred Moore is listed, without company affiliation, as "ctr" [i.e., contractor] in 1915 (p. 1272) and as "civeng" [i.e., civil engineer] in 1916 (p. 1065).

[147] "LOED Corporation History," 4 September 1975, in LOED Collection, State Historical Society of Wisconsin. LOED Corporation is a successor to Wausau Iron Works. Although this brief history does not mention Krause, the formal incorporation papers (16 June 1908) list three individuals: A. C. Heinzen, Henry Ellenbecker, and Fred W. Krause; see Diane Kromm, "Marathon City Bridge," Historic American Engineering Record Report, HAER No. WI-37, 3.

That same year, Wausau Iron Works built a 20,000-square-foot facility, and by 1911, was worth $50,000. The company expanded its plant again in 1916, and by 1926, had increased its worth to $400,000. In 1930, the company expanded its plant again.[148]

In 1919, the company went into concrete paving as an extension of its bridge-erecting business. The firm added snowplows in the 1920s through a subsidiary arrangement with E.A. Drott, the state sales representative of Caterpillar Tractors. Wausau Iron Works dropped its bridge erection and concrete paving business in 1933, apparently in response to a new SHC system of qualifications for bidding on contracts.[149] According to Elmer Krienke, a former employee of Wausau Iron Works, the SHC's new rules were in response to complaints from small bridge builders and contractors that the big firms who did both the fabrication and erection had an unfair monopoly.[150]

In the 1930s, Tony Heinzen sold out to his brother, John.[151] The company apparently continued to fabricate steel for bridges and to manufacture snow plows and steel warehousing. The company was involved in bridge fabrication as late as 1951.[152] The plant moved to a new location in Wausau in 1953. The firm was legally dissolved in 1984.[153]

Wausau Iron Works built two impressive Pennsylvania trusses in Clark County. The earlier one was Hemlock Bridge on Warner Drive over the Black River, built in 1914. This bridge, featuring a 200-foot center span, was determined eligible for the National Register in 1980, and a report

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[148] Kromm, "Marathon City Bridge," 3; "LOED Corporation History."

[149] "LOED Corporation History"; Wisconsin State Highway Commission, Minutes, vol. 13 (1 Jan. 1931 to 1 July 1931) 91-96; vol. 15 (1 Jan. 1932 to 1 July 1932) 66, 129-134.

[150] Danko, interview with Krienke, Tape 1, Side 1, Part 1. "LOED Corporation History" is ambiguous on this point.

[151] Danko, interview with Krienke, Tape 5, Side 1, Part 1.

[152] See plans for B-61-014 on State Highway 95 over the Trempeleau River, on microfilm, Bridge Section, Wisconsin Department of Transportation; the LOED Collection contains company correspondence dated as late as 1952 concerning bridge construction.

[153] Kromm, "Marathon City Bridge," 3.

documenting its significance was prepared prior to its demolition in 1984.[154] In 1940, the firm built the Lynch Bridge (P-10-266) on River Road over the Black River, about 25 miles downstream from the location of the Hemlock Bridge. The Lynch Bridge was of interest because it used design details of a decade or more earlier.[155] Historic American Engineering Record documentation was prepared for this bridge before its 1992 replacement.[156]

Wisconsin Bridge and Iron Company

Friederich Weinhagen came to the United States after the Civil War at the age of 16. He settled in Milwaukee, and by 1886, he was an agent for the Penn Bridge Works, although he also built at least one bridge under his own name. By 1887, he had formed the Wisconsin Bridge and Iron Company.[157] With his brother Berthold, a civil engineer, he formed a joint proprietorship in 1888. The company was incorporated in January 1891. The two brothers ran the company until Berthold left the firm in 1900. Friederich remained actively involved with the company at least until 1910, when he became president of A. George Schultz Company, a Milwaukee box manufacturer.[158]

The incorporation papers list Berthold Weinhagen, William Hinrich, and Herman A. Wagner. With capital stock of $100,000, the company contracted and built bridges, as well as manufactured general iron work. The company offices were in Milwaukee, while the plant was

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[154] Robert S. Newbery, "The Hemlock Bridge," Historic American Engineering Record Report, HAER No. WI-5, 3.

[155] Robert S. Newbery, Field Inspection, 21 December 1982; and Robert M. Frame III, Truss-Bridge Intensive Survey Form for Black River Bridge (P-10-266), Wisconsin Department of Transportation, 1986.

[156] "Lynch Bridge," Historic American Engineering Record Report, HAER No. WI-63, 1993.

[157] Danko, "Selective Survey" 61. The 1887 Mill Road Bridge (P-36-022) in the Town of Manitowoc Rapids, Manitowoc County, had a bridge plate listing Wisconsin Bridge and Iron Company as the builder. This bridge has been replaced.

[158] See Kromm, "Marathon City Bridge"; Milwaukee City Directory, 1869-1927 editions.

initially located in Wauwatosa, west of Milwaukee. By 1892, company officials agreed to build an extensive plant in the new suburb of North Milwaukee, to be erected by the spring of 1893 (see Figures 52 and 53). In addition to the main building, which measured 200 feet by 300 feet, the plant included several smaller buildings, including offices, paint shops, and storerooms. The company spent $45,000 on buildings and $40,000 on machinery. The plant continued to operate at this location until 1929, when it moved to North 35th Street, Milwaukee.

In 1901, Wisconsin Bridge and Iron proudly advertised, "Not in any Trust," and the company apparently was able to compete with the American Bridge Company.[159] In 1904, the stockholders approved increasing the capital stock to $300,000. Business continued to expand; six years later, company stock value increased to $500,000. By 1936, the company was worth $1 million. Wisconsin Bridge and Iron established two branch facilities in the state, in Oxford and Antigo. The Oxford structures division manufactured farm building packages. The company ceased operations in 1983.[160]

Worden-Allen Company

This company was founded shortly after the turn of the century while Beverly Lyon Worden was still construction engineer for Wisconsin Bridge and Iron Company.[161] The firm may have been more Worden than Allen, as Clarence J. Allen appears to have been associated with the company, as

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[159] Wisconsin State Gazetteer and Business Directory, 1901-1902 673.

[160] Wisconsin Bridge and Iron Company, "Articles of Incorporation and Amendments," in Office of Wisconsin Secretary of State, Corporation Division; Milwaukee Sentinel 24 April 1888; "Ready to Begin Work" Evening Wisconsin 24 September 1892; "New Leader at Steel Firm," newspaper clipping dated January 1973 in Wisconsin Bridge and Iron Company, Microfilm Clipping File, Milwaukee County Historical Society. This last article states that the company was 102 years old in 1973, but there is no evidence of the firm starting in 1870 or 1871.

[161] At least two sources give the date of founding as 1901; Who's Who in America 2416; Fred L. Holmes, ed., Wisconsin (Chicago: Lewis Publishing Co., 1946) 134. The company did not advertise until 1903; Wright's Directory of Milwaukee for 1903 1270, 1321.

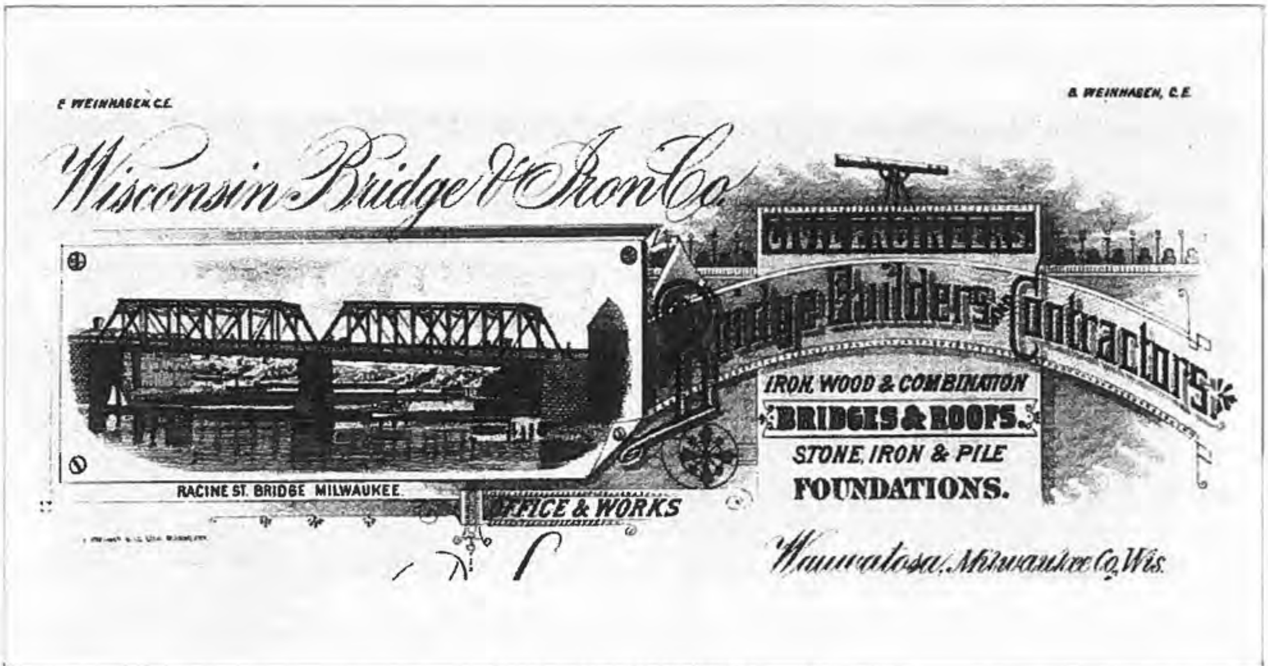

Figure 52: Letterhead of the Wisconsin Bridge & Iron Company, Wauwatosa, Wisconsin, 1889. (Source: Bridge Section files, WisDOT).

Figure 53: Advertisement of the Wisconsin Bridge & Iron Company, 1893. (Source: Wright's Directory of Milwaukee, 1893).

secretary-treasurer, from the founding only until 1907. Although the name always remained Worden-Allen, Beverly Worden achieved far more prominence.[162]

Worden was born in Chicago in 1871. He worked in the Milwaukee Public Library before becoming an engineer. Presumably, he was an apprentice engineer at Wisconsin Bridge and Iron Works before he received a degree in civil engineering from the University of Wisconsin in 1893.[163] After getting his degree, he listed himself first as a civil engineer, then, in 1895, as a bridge engineer, and then, from 1896 to 1902, as a contracting or construction engineer.[164] The latter term may have referred to a superintendent position with Wisconsin Bridge and Iron Company.[165]

Worden-Allen Company was formally incorporated in December 1902. It soon became one of the largest twentieth-century bridge companies in the Midwest, with offices in Chicago, Milwaukee, and Houghton, Michigan. By 1911, the firm had a structural steel capacity of 12,000 to 15,000 tons per year and grossed over $1 million annually.[166]

Worden-Allen built a number of Warren pony trusses based on the standardized plans of the Wisconsin SHC. The company also built the first known riveted Pratt overhead truss in Wisconsin in 1909. This was a design that the SHC advocated in its 1912 set of standard plans.[167] Also in 1909,

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[162] Wright's Directory of Milwaukee for 1907 lists only Allen's home address; no company affiliation is given; 108. Perhaps Allen provided the original capital and Worden the engineering expertise.

[163] Beverly Worden is listed as an engineer in 1889 and as a student in 1892; Wright's Directory of Milwaukee for 1889, 881; 1892, 1001. Sheets 1 and 2 of the plans for the Hewitt Street Bridge, Neillsville, Clark County, built by Wisconsin Bridge and Iron in 1892, were checked by "Worden." Sheet 3 was made by "Worden." Copies are in possession of the author. For information on the university degree, see Holmes 134.

[164] Wright's Directory of Milwaukee for 1893 1076; 1894 1099. Worden first lists his association with Wisconsin Bridge and Iron in 1900, but he gives the same business address as early as 1897; Wright's Directory of Milwaukee for 1897 1022; 1900 1141.

[165] "Beverly L. Worden," obituary, Milwaukee Journal 28 March 1931.

[166] Danko, "Selective Survey" 25.

[167] For a discussion of SHC standard plans, see the section on "Design and Engineering" in Chapter 2. The riveted Pratt is on Wagon Trail Road in Pierce County (B-47-006). This bridge was set aside in 1996 and advertised (continued...)

Worden organized a subsidiary bridge company, the Lackawanna Bridge Company, with offices in Milwaukee, Buffalo, and New York. In 1921, Lackawanna also advertised itself as "General Contractors for Fireproof Construction."[168] In the years before World War I, Worden apparently commuted between Milwaukee and the east.[169] Worden-Allen Company continued to build bridges in Wisconsin as late as 1933.[170]

During World War I, Worden was called upon by the government to assist in the war effort. As general manager of the Newark Bay Shipyard, in Newark, New Jersey, he oversaw the completion of 150 ships for the Emergency Fleet Corporation. He is said to have "turned the preconceived ideas of shipbuilding topsy-turvy." His contribution apparently involved standardized plans and construction techniques. After the war, Worden became president of Cutler-Hammer, Inc., of New York and Milwaukee, the "foremost business of its kind in the field of electrical controls." He was also a director of Buffalo Sand and Gravel Company.[171]

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[167](...continued)
for relocation.

[168] Danko, "Selective Survey" 25; Engineering News-Record 86 (30 June 1921), 126.

[169] Holmes 134; "Beverly L. Worden."

[170] The contract for the Wrightstown Bridge (Job No. 3391) was awarded to Worden-Allen Company for $158,290.59 on 14 November 1933; Wisconsin State Highway Commission, Minutes, vol. 18, Wisconsin Department of Transportation, 315.

[171] Holmes 134; "Beverly L. Worden." According to his latter source, Worden's shipbuilding firm was "known as the Submarine Boat Co." and was at one point "40 days ahead of schedule in building ships to check the menace of German submarine warfare."

CHAPTER 5

AESTHETICS

At the end of the nineteenth century, the truss bridge gained popularity due to its relatively economical cost and ease of construction. In Volume I of this series, Hess and Frame found the aesthetic aspects of stone and concrete arch bridges to be important and integral components of their story. As a shape, the arch had long been perceived as inherently graceful and artistic. The materials, stone and concrete, provided an artistically creative opportunity for the bridge designer. Stone construction could focus on color, texture, and craftsmanship while concrete had a plastic nature that was readily adaptable to a variety of artistic efforts.[172] The metal truss, on the other hand, offered a practical solution for many river crossings.

From a historical perspective, the metal truss bridge did not exhibit the aesthetic character of a stone or concrete arch. However, its aesthetics should not be dismissed outright. During the height of truss bridge construction, these structures were heavily criticized as astylistic. Figures 54 and 55 depict typical, late nineteenth-century bridges that may have been the targets of such criticism. In 1890, Alfred Boller wrote that the problem with truss bridges was that they offered so little opportunity for architectural effect, beyond choosing what color to paint them. This would be true, he claimed, even if significant financial resources were available.[173]

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[172] Jeffrey A. Hess and Robert M. Frame III, Wisconsin Stone-Arch and Concrete-Arch Bridges, Volume 1: Highway Bridges in Wisconsin, (Madison, Wis.: Wisconsin Department of Transportation, 1986), 219-35. Hess wrote the section on stone arches. According to Frame, author of the concrete arch section, chronological periods based on style are as important as those based on engineering developments. On the aesthetic potential of concrete's plastic nature see also, "A Protest Against Ugly Bridges," Engineering News 10 Oct. 1912: 682.

[173] Alfred P. Boller, Practical Treatise on the Construction of Iron Highway Bridges, Fourth edition, 1890, 87.

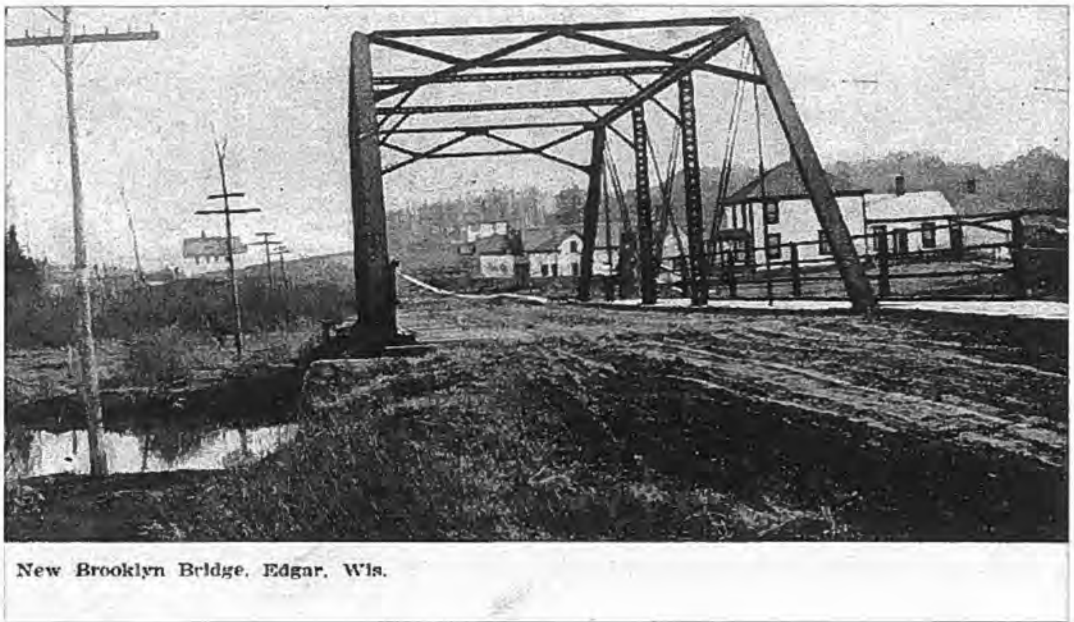

Figure 54: The New Brooklyn Bridge in Edgar, Wisconsin, is a typical example of a late nineteenth century truss bridge. (Source: Collection of Robert Newbery).

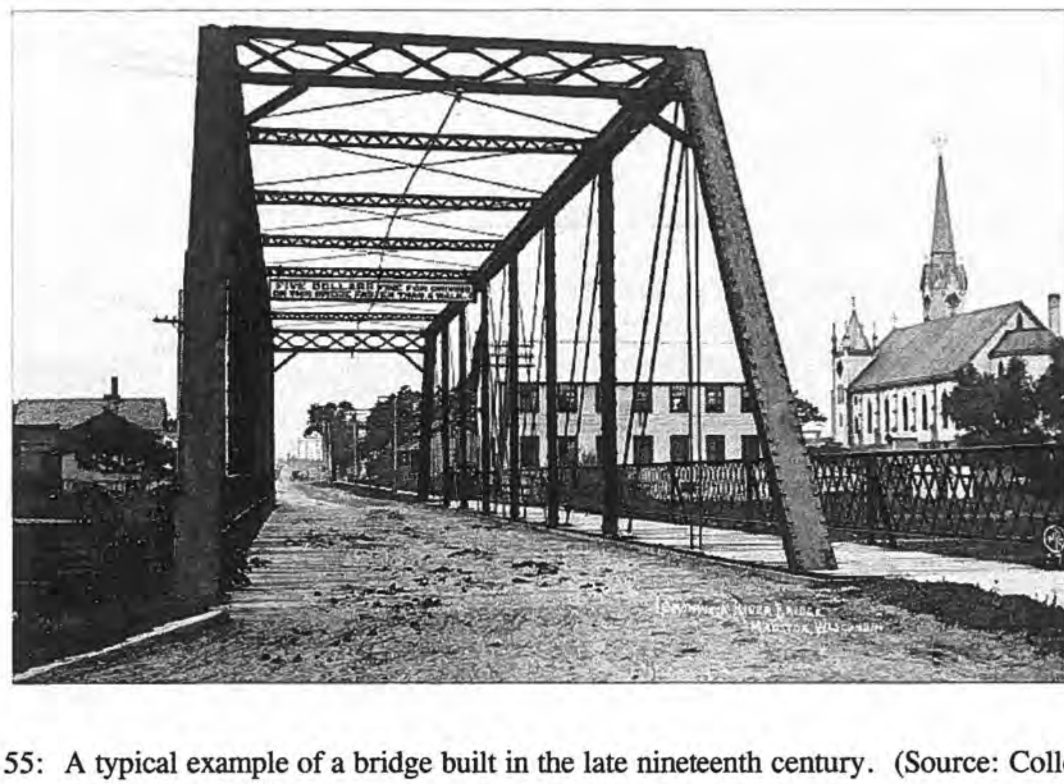

Figure 55: A typical example of a bridge built in the late nineteenth century. (Source: Collection of Robert Newbery).

J. A. L. Waddell singled out the camelback truss as "uncompromisingly ugly." Others focused on other truss types and used different adverbs, but the adjective stayed the same: ugly. Some trusses, it was charged by engineer and laymen alike, disfigured their surroundings and detracted from the architectural beauty of nearby buildings. One recommendation was that truss bridges be banned to remote rural areas where "they would be seldom or never seen."[174] Figure 56 demonstrates how one truss bridge dominated its urban landscape in opposition to this proposed ban. In contrast, Figure 57 depicts a concrete arch bridge in a similar urban setting that may be seen as less imposing on its surrounding environment.

Clearly, times have changed and current evaluations are not only less harsh, they are sometimes quite positive. Lavish photography books and calendars give prominent play to truss bridges, and professional photographers have made images of industrial structures an art form.[175] Emory Kemp finds that even bridges with "pure structure" have aesthetic values.[176] The Manchester Street Bridge in Baraboo is exactly the type of truss bridge that would have been scorned by early commentators but is valued by modern critics (see Figure 58).

Aesthetic taste fluctuates with time; therefore, bridges deemed "ugly" in the past can be considered "attractive" when viewed from a contemporary perspective. Nostalgia for a bygone industrial past may contribute to the current artistic appreciation of utilitarian structures. Recently,

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[174] J.A.L. Waddell, Bridge Engineering 478. Charles Evan Fowler agreed that the camelback was "unsightly," see Fowler, Ideals of Engineering Architecture (Chicago: Gillette Publishing Company, 1929) 161. Henry Grattan Tyrrell, in Artistic Bridge Design (Chicago: The Myron C. Clark Publishing Co., 1912), called the common truss "inexpressibly ugly," 24 and 27. For the Engineering News, the swing truss was "awkwardly ugly," see "The Design of Movable Bridges," Engineering News 5 Nov. 1896: 297.

[175] See for example, Eric DeLony, Landmark American Bridges (New York: Published in association with the American Society of Civil Engineers and Boston: Little Brown & Co., 1993), where over one-third of the featured bridges are trusses. Similarly, Jet Lowe's Industrial Eye, Photographs by Jet Lowe from the Historic American Engineering Record (Washington, D.C.: Preservation Press, 1986), features a number of truss bridges.

[176] Kemp, "Exemplars of Engineering," 727 (also cited in the introduction to this study).

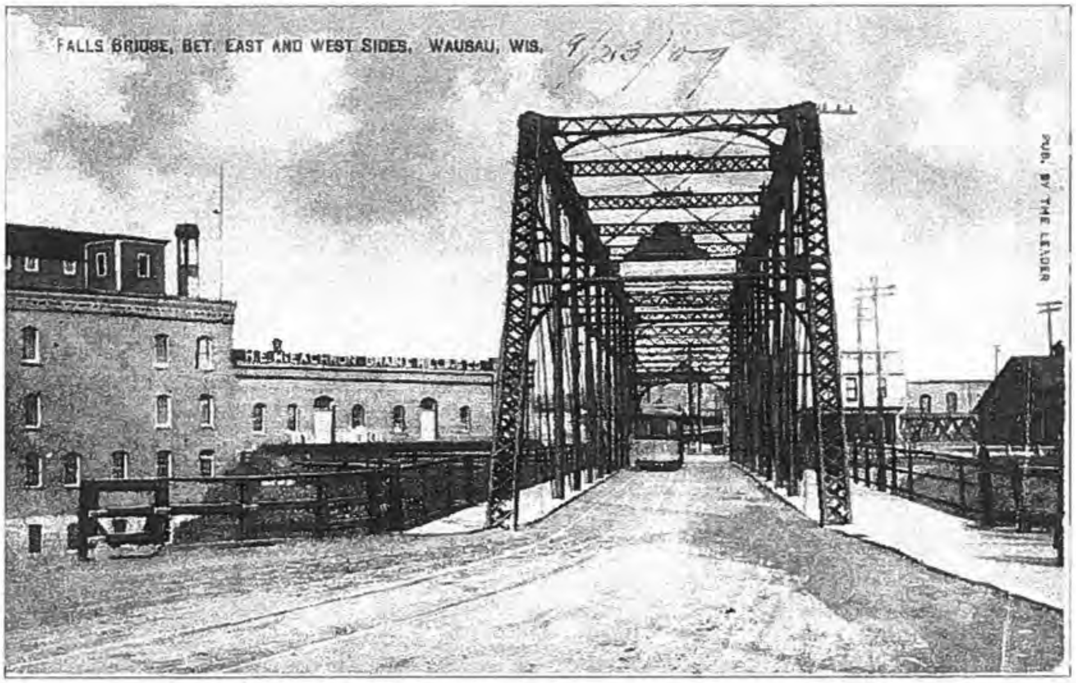

Figure 56: The Falls Bridge in Wausau, Wisconsin, dominated the landscape around it. (Source: Collection of Robert Newbery).

Figure 57: The new concrete bridge in Wausau, Wisconsin. (Source: Collection of Robert Newbery).

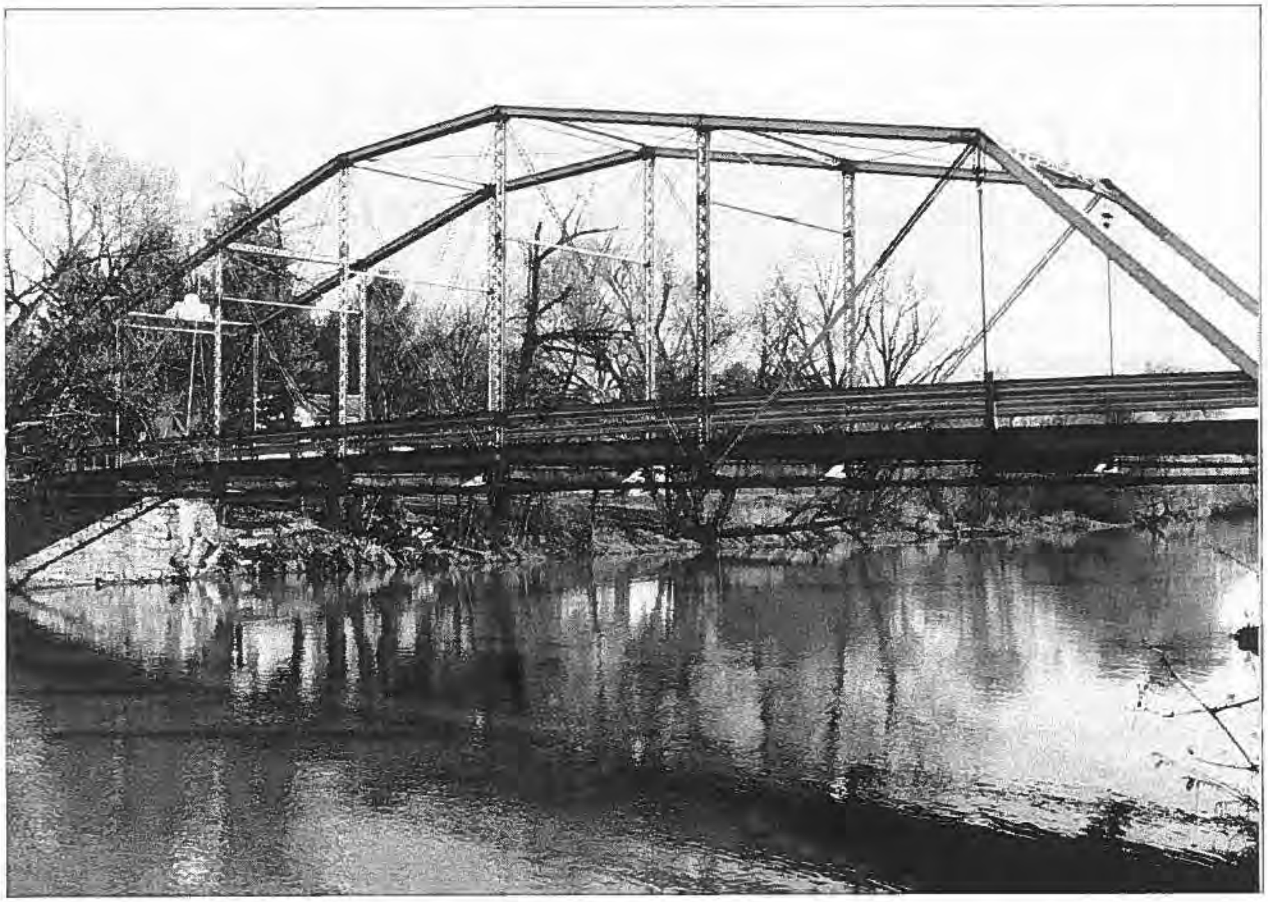

Figure 58: The Manchester Street Brige (P-56-703) in its current location. (Source: WisDOT).

the truss bridge even made a limited comeback when it was chosen for a new crossing in Charleston, South Carolina, that required a substantial span. A major requirement of the design contract was aesthetics.[177] Communities have also demonstrated their appreciation for truss bridges in committing significant resources to the restoration of deteriorated structures. For example, the city of Chattanooga,Tennessee, recently restored the Walnut Street Bridge, a camelback Pratt overhead truss, for pedestrian use.

Although aesthetic tastes of the past and the present diverge, a closer look at the factors that originally influenced truss bridge design merits consideration. Historically, there were at least three reasons why a beautiful truss design was not seriously explored. These reasons, which were based upon functionality and economy, led to design limitations. First, as late as the 1890s, important points of engineering and metallurgy were still being debated. The lack of confidence in materials and design resulted in bridges that appeared either too thin and flimsy or too massive and cluttered. The second reason is that trusses were by definition angular and simply could not meet the aesthetic standards of the day, which had deemed the arch to be artistic.[178] Finally, economy, not artistry, was what buyers of truss bridges expected.

Local units of government typically needed low cost and reliable structures. It should not come as a surprise that utilitarian considerations governed design.[179] To be fair, one must remember the context. The older bridges that trusses often replaced offered little in the way of aesthetic reward. For example, the hand-built, timber bridges in Figures 59 and 60, illustrate typical utilitarian structures of the nineteenth century.

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[177] John J. Corigliano, "Longest Bridge in State Designed for Charleston," HNTB Magazine Summer 1987: 6-7; and John J. Corigliano, "New South Carolina Spans Incorporate Steel, Concrete," Roads and Bridges Nov. 1987: 48-49.

[178] Charles Evan Fowler, Ideals of Engineering Architecture (Chicago: Gillette Publishing Company, 1929) 161; and David A. Molitor, "The Aesthetic Design of Bridges," Chapter 26 in Johnson et al. 449-64.

[179] Plowden, p.296.

The two most promising ways to beautify a truss bridge were to decorate some of the functional connections and to incorporate curves into the overall design.[180] Enhancing the intersections of lattice work on the railings with small rosettes is one of the more successful examples of this attempt (see Figure 61). Knee braces, portal struts, and cast-iron joint-boxes could all be designed to be artistically pleasing. Bridge plates and decorative portals could also show flair for design (see Figure 62). The Grand Avenue Bridge in Neillsville, one of Wisconsin's most elaborately decorated trusses, used rosettes on the railing, an elaborate portal punched with the bridge's name and decorative finial posts (see Figure 29). Although these decorative enhancements offered the nearby observer an aesthetically improved view, such treatments did nothing to the overall form of the truss bridge. From a distance, these bridges retained their massive structural form. In the case of overhead trusses, the bridges continued to overpower the surrounding landscape.

The exalted aesthetic position of the arch may have led some engineers to experiment with curves in truss designs, combining elements of the arch and the truss.[181] The most successful example of a combined arch and truss design is the bowstring. This practical design was once relatively common in Wisconsin. Examples were found spanning short crossings in Elroy and Watertown (see Figures 63 and 64). In bowstring bridges, modest curves could also be incorporated into functional elements such as knee braces, cross bracing, and portals.[182] Long-span, overhead examples were also erected in the state, including those at Three Lakes and Wauwatosa (see Figures 65 and 66). Today,

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[180] Fowler, Ideals of Engineering Architecture, is the most optimistic and the most expansive about the possibilities of aesthetic treatments, particularly the use of curves, for truss design.

[181] According to the Engineering Record, the arch was "one of the most graceful bridge structures which civil engineers have yet designed," Engineering Record 40.22 (1899): 497. Translating this beauty to truss designs was, however, problematic. "The Third Avenue Drawbridge over the Harlem River; New York City," Engineering News 5 Nov. 1896: 290.

[182] Fowler, Ideals, 154, 158-60 and 163.

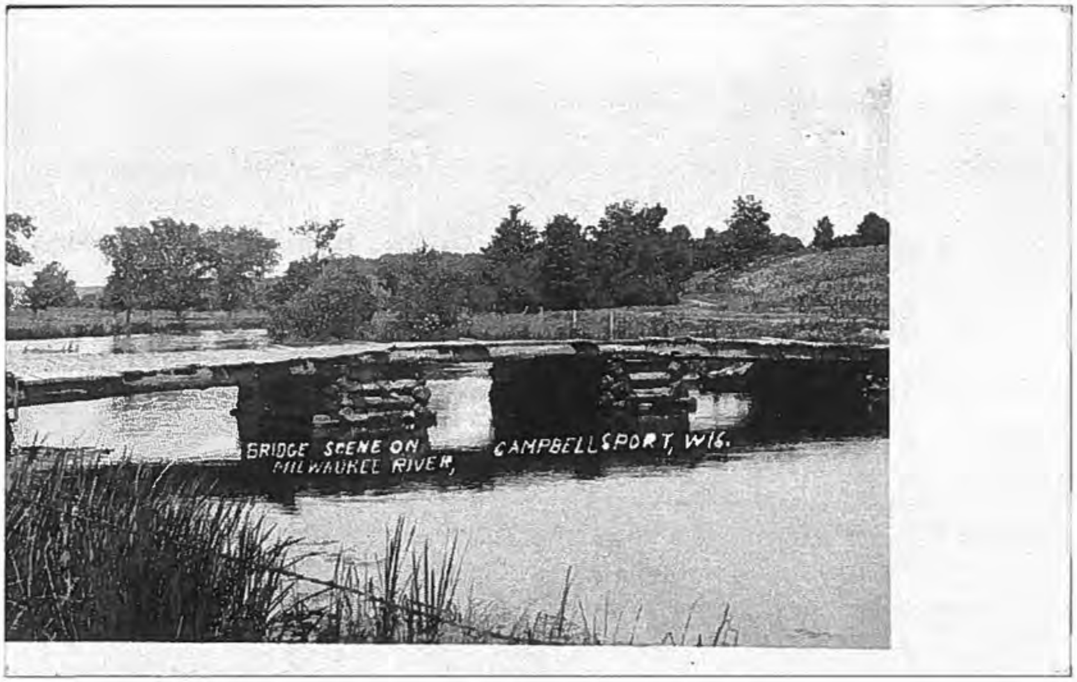

Figure 59: Timber bridge over the Milwaukee River in Campbellsport, Wisconsin. (Source: Collection of Robert Newbery).

Figure 60: The Gernetkge Bridge was a typical utilitarian structure of the nineteenth century. (Source: Collection of Robert Newbery).

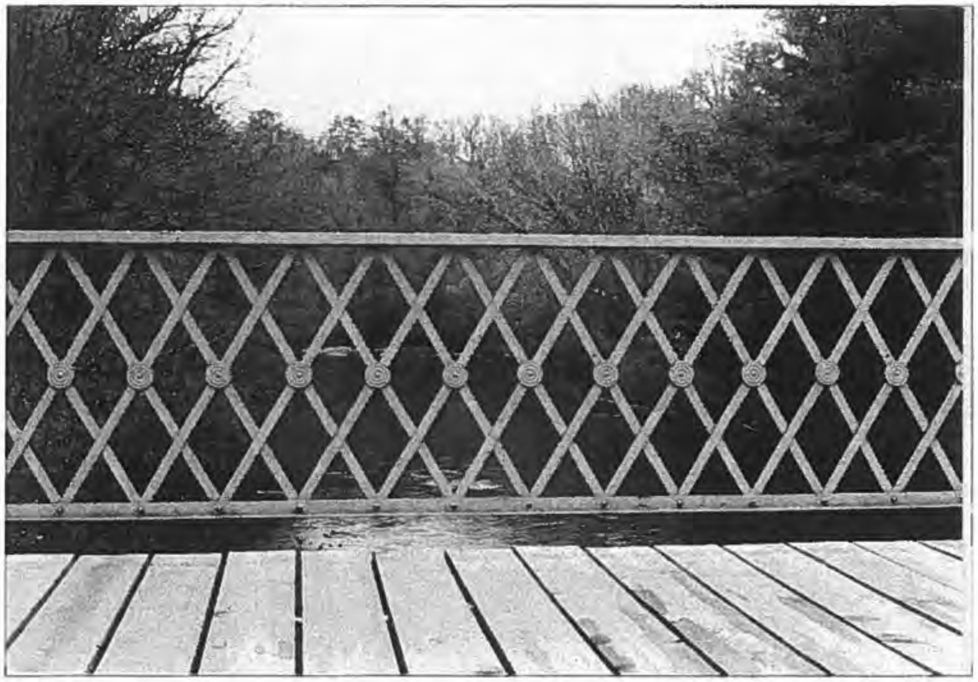

Figure 61: The decorative railing of the Irvine Park Main Bridge (P-09-709) in Chippewa Falls, Wisconsin. (Source: WisDOT).

Figure 62: The Milwaukee Street Bridge in Watertown, Wisconsin, displays decorative bridge plates and portals. (Source: Collection of Robert Newbery).

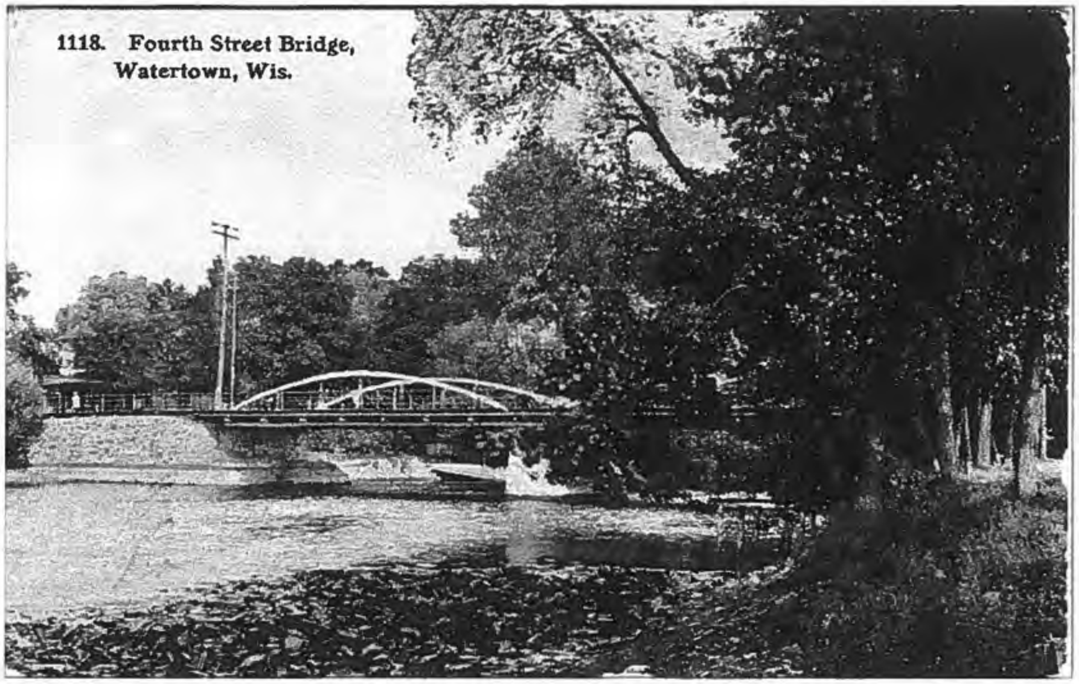

Figure 63: The Fourth Street Bridge in Watertown, Wisconsin, is an example of a bowstring truss. (Source: Collection of Robert Newbery).

Figure 64: A bowstring truss located in Elroy, Wisconsin. (Source: Collection of Robert Newbery).

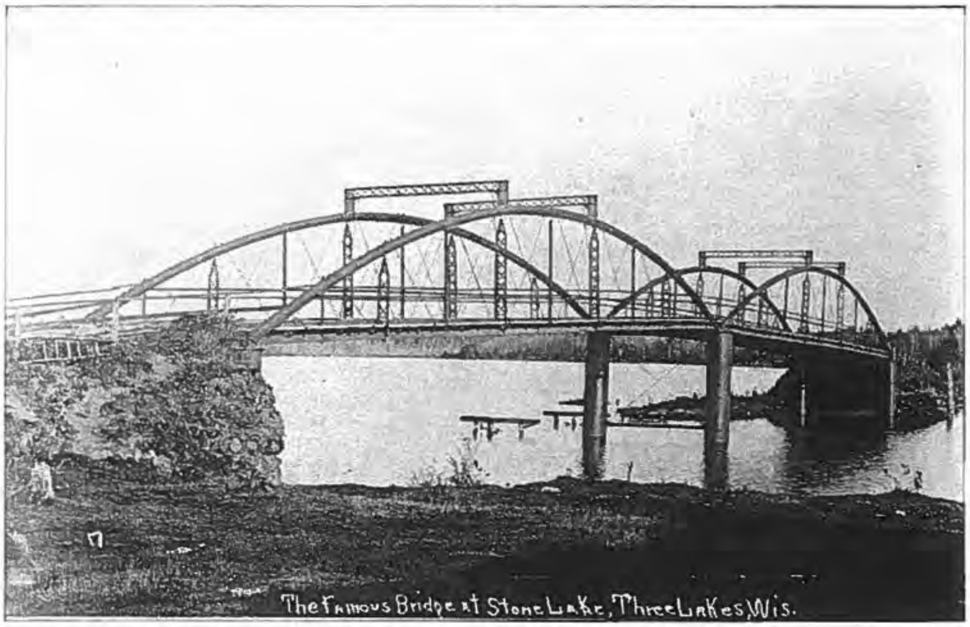

Figure 65: An excellent example of an overhead bowstring truss is the Famous Bridge at Stone Lake, Three Lakes, Wisconsin. (Source: Collection of Robert Newbery).

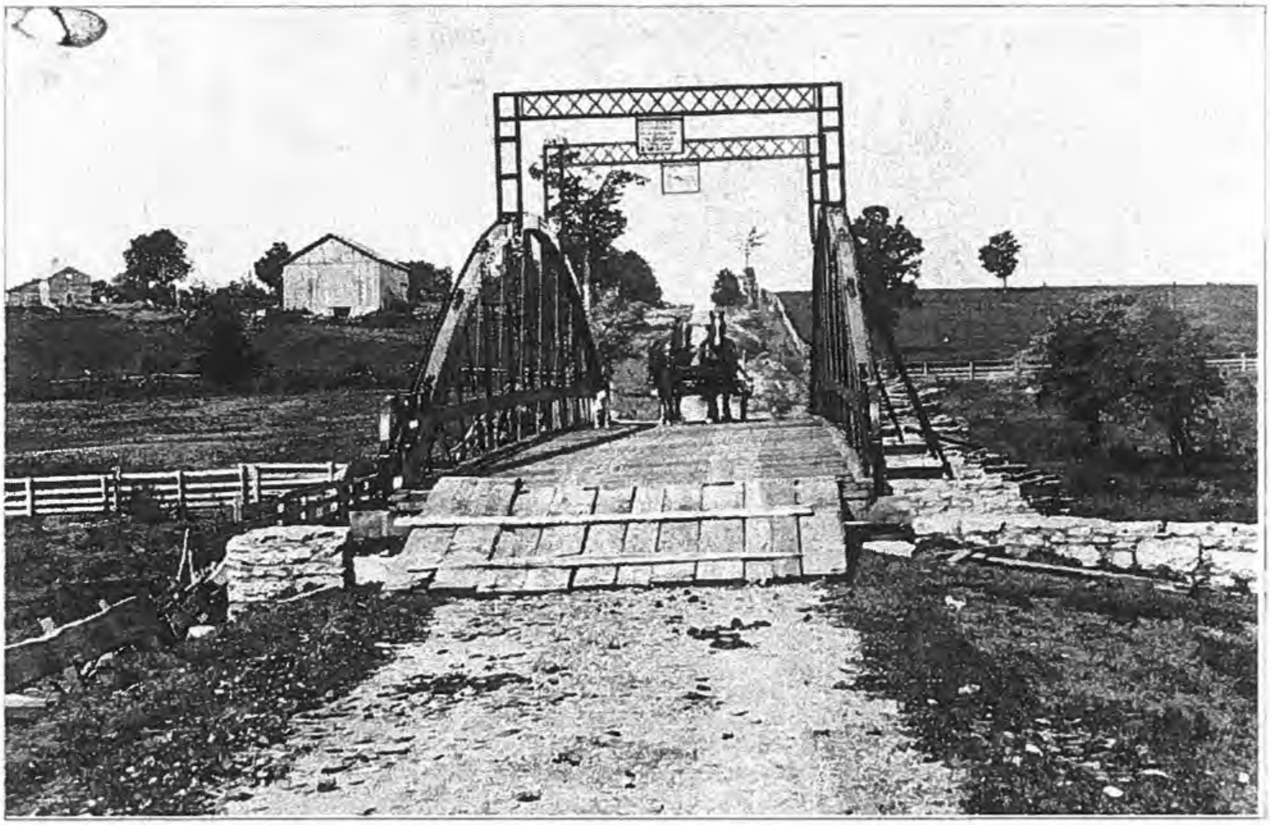

Figure 66: The West Main Street Bridge in Wauwatosa, Wisconsin, is an example of an overhead bowstring truss bridge. (Source: Courtesy of the Milwaukee County Historical Society).

no bowstring bridges remain on Wisconsin's public highways. Excellent examples have been preserved in parks, including the five bowstring bridges found within the Van Loon Wildlife Area.[183]

In 1916, the Wisconsin State Highway Commission (SHC) stated in its Third Biennial Report that "the aesthetic in bridge construction has not received the attention it deserves. Bridges should not only be substantial, they should be pleasing to the eye as well." One reason that truss designers had not given more attention to this deserving aspect of bridge design, the SHC explained, was the taxing volume of recent bridge work. The commission promised to remedy the situation in the future, but there is no evidence that aesthetics came to play a larger role. Moreover, most of the SHC's artistic efforts after 1916 appear to have been directed at concrete structures.[184]

Many of the SHC's standardized truss designs of the 1920s and early 1930s are, by today's standards, less pleasing than the light, gossamer structures of the nineteenth century. Strengthened for automobile and truck traffic, these later trusses have a cluttered appearance with too many heavy web members and top heavy lateral bracing. Thus, from a modern perspective it can be argued that the late 1920s and early 1930s saw a regressive trend in truss aesthetics in which practical solutions yielded stodgy, heavy designs. In the late 1930s, the SHC updated its standardized plans and dropped the Pratt, and related Parker, design in favor of the Warren for overhead trusses. Although it is unlikely that aesthetics played a major role in the SHC's switch from the Pratt overhead truss to the Warren, the cleaner lines of the latter were in keeping with changing aesthetic values. The trend away from bolstering traditional designs and toward clean, uncluttered lines can be seen in comparing the 1928 Beyer Bridge (P-42-042), a Pratt overhead, with the 1937 State Trunk Highway 78/81 Bridge, a Warren overhead truss (see Figures 67 and 68). The 90-foot, single-span Beyer Bridge, located on

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[183] Some bowstrings have been preserved in parks in Wisconsin: Fountain Island Bridge in Lakeside Park, Fond du Lac (constructed c.1870); Tivoli Island Bridge over the Rock River in Watertown (constructed c.1877); and McGilvray Road Bridges in the Van Loon Wildlife Area in La Crosse County (constructed 1891-1892).

[184] Wisconsin State Highway Commission, Third Biennial Report (Madison, Wis.: Wisconsin State Highway Commission, 1916) 13.

Smyth Road in Oconto County, has the heavy appearance typical of the late 1920s.[185] The 282-foot, two-span State Trunk Highway 78/81 Warren overhead in the village of Argyle, Lafayette County, exemplifies the clean look that became prominent after the SHC's switch to the Warren overhead for its standard plan.[186]

Any movement toward a new aesthetic in truss bridge design ended with the decline of truss construction after World War II. Truss bridges fell out of favor as attention shifted toward concrete and steel girder structures. During the 60-year period around the turn of the twentieth century when trusses were the design of choice for most crossings, these bridges never achieved their aesthetic potential. Truss bridges remained in conflict with the basic established aesthetic principles of their day and their engineers failed to fully exploit the potential of truss design or the bridges' material.

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[185] An intensive survey form for the Beyer Bridge (P-42-042) is included in Appendix A2 of this study.

[186] This bridge is scheduled for demolition in 1998.

Figure 67: The STH 78/81 (Argyle) Bridge (P-33-088) displays the clean look of the SHC's Warren overhead standard plan. (Source: WisDOT).

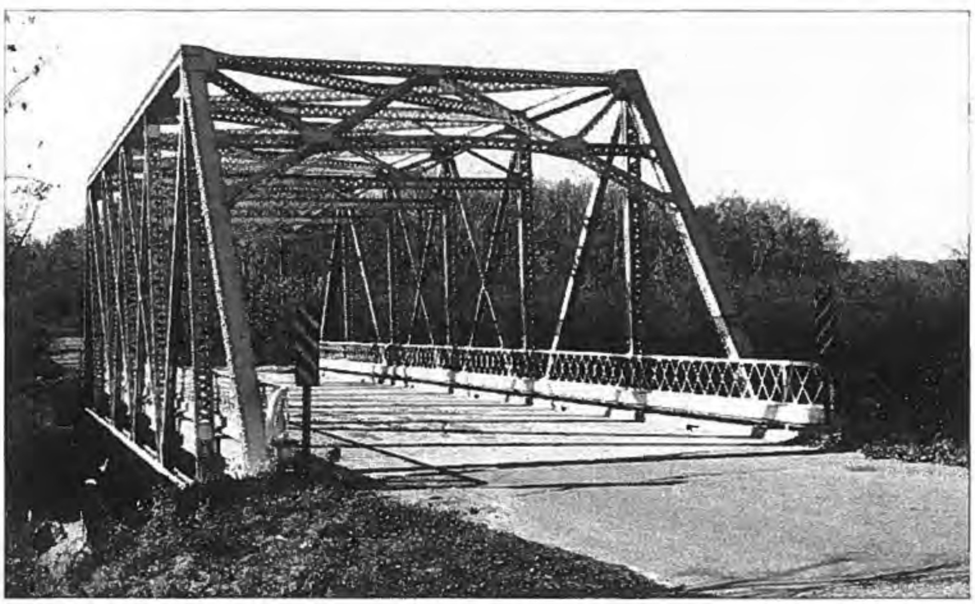

Figure 68: The Beyer Bridge (P-42-042) displays the traditional design of a Pratt overhead plan. (Source: J.A. Hess).

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Attachment

1986 Summary Description of Truss Bridges that are
Eligible for the National Register
(1996 status noted)

Pony Trusses[187]

Bedstead (Truss Leg)

P-66-055 (c. 1910), 1 span, 40' long, pin-connected, fabricator unknown, Town of Addison, Washington County, Beaver Dam Road over Rock River. (Current status: extant as of 8/96)

Allenton Park Bridge, no number assigned (1896), 1 span, 41' long, pin-connected, Milwaukee Bridge and Iron Works, Town of Addison, Washington County, Rock River Drive, over Rock River. (Current status: Extant as of 1996).

King Post

P-45-714 (date of fabrication unknown; moved to site from another location, ca. 1925), 1 span, 41' long, riveted, fabricator unknown, City of Port Washington, Ozaukee County, access road over Sauk Creek in Port Washington harbor area. (Current status: replaced in 1988)

Parker

B-37-537 (1931), 2 spans, each 91' long, riveted, Wausau Iron Works (plans by Wisconsin State Highway Commission), City of Schofield, Marathon County, US Highway 51 Business (Grand Avenue) over Eau Claire River. (Current status: scheduled for replacement)

Pratt, Full-Slope

P-23-124 (1907), 2 spans, each 87' long, pin-connected, Elkhart Bridge and Iron Company, Town of Decatur, Green County, Ten Eyck Road over Sugar River. (Current status: scheduled for replacement)

P-36-022 (1887), 1 span, 150' long, pin-connected, Wisconsin Bridge and Iron Company, Town of Manitowoc Rapids, Manitowoc County, Mill Road over Manitowoc River. (Current status: extant as of 8/96)

P-36-116 (ca. 1900), 1 span, 92' long, pin-connected, fabricator unknown, Town of Franklin, Manitowoc County, Hillcrest Road over Branch River. (Current status: replaced in 1990)

P-54-107 (ca. 1910), 1 span, 75' long, riveted, fabricator unknown, Town of Grant, Rusk County, Larson Road over Deer Tail Creek. (Current status: replaced in 1989)

P-54-125 (1907), 1 span, 60' long, pin-connected, Security Bridge Company, Town of Willard, Rusk County, Broken Arrow Road over Deer Tail Creek. (Current status: replaced in 1987)

P-58-111 (1900), 1 span, 90' long, pin-connected, Wisconsin Bridge and Iron Company, Town of Grant, Shawano County, Blomberg Road over Embarrass River. (Current status: replaced in 1994)

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[187] Current eligibility status should be reevaluated for each bridge.

Pony Trusses Cont'd.

Pratt Full-Slope Cont'd.

P-60-125 (1906), 2 spans, each 75' long, pin-connected, Hennepin Bridge Company, Town of Hammel, Taylor County, Sawyer Avenue over Black River. (Current status: scheduled for replacement)

P-65-051 (1907), 1 span, 52' long, riveted, Joliet Bridge and Iron Company, Town of Long Lake, Washburn County, Bridge Road over Brill River. (Current status: replaced in 1987)

Pratt Half-Hip

P-23-121 (1906), 1 span, 79' long, pin-connected, Wisconsin Bridge and Iron Works, Town of Decatur, Green County, Decatur Road over Sugar River. (Current status: replaced in 1990)

P-29-092 (1913), 2 spans, each 59' long, pin-connected, Elkhart Bridge and Iron Company, Towns of Armenia and Necedah, Juneau County, East Ninth Street over Yellow River. (Current status: moved)

P-36-088 (1903), 1 span, 75' long, pin-connected, Wisconsin Bridge and Iron Company, Town of Gibson, Manitowoc County, Nachtway Road over Neshota River. (Current status: extant as of 8/96)

P-52-224 (1886; possibly moved to site from another location at later date), 1 span, 39' long, pin-connected, Penn Bridge Works, Town of Buena Vista, Richland County, St. Killian Road over Bear Creek. (Current status: extant as of 8/96)

P-56-147 (1894), 1 span, 37' long, pin-connected, Wisconsin Bridge and Iron Company, Town of Freedom, Sauk County, Klein Road over Seeley Creek. (Current status: replaced in 1991)

Queen Post

P-16-097 (ca. 1930), 1 span (wooden), 41' long, bolted, fabricator unknown, Town of Amnicon, Douglas County, Bayfield Road over Middle River. (Current status: scheduled for replacement)

Warren, Standard

B-38-901 (1929), 1 span, 70' long, riveted, Wausau Iron Works (plans by Wisconsin State Highway Commission), Town of Grover, Marinette County, State Trunk Highway 64 over Little Peshtigo River. (Current status: extant as of 8/96)

P-02-033 (date of fabrication unknown; moved to site from another location, ca. 1925-1930), 1 span, 75' long, riveted, fabricator unknown, Town of White River, Ashland County, Town Road over Marengo River. (Current status: extant as of 8/96)

Pony Trusses Cont'd.

Warren, Standard Cont'd.

P-33-217 (1917), 1 span, 65' long, fabricator unknown, designed by Wisconsin State Highway Commission, Towns of New Diggings and Benton, Lafayette County, Horseshoe Bend Road over Fever River. (Current status: moved)

P-34-060 (1908), 1 span, 59' long, riveted, Wisconsin Bridge and Iron Company, Town of Ackley, Langlade County, Range Line Road over West Branch of Eau Claire River. (Current status: replaced in 1991)

P-35-032 (1922), 1 span, 60' long, riveted, fabricator unknown, designed by Wisconsin State Highway Commission, Town of Harding, Lincoln County, County Trunk Highway E over New Wood River. (Current status: replaced in 1989)

P-36-089 (1910), 1 span, 80' long, riveted, Worden Allen Company, Town of Gibson, Manitowoc County, Melnik Road over West Twin River. (Current status: extant as of 8/96)

P-62-320 (ca. 1912; may have been moved to site from another location), 1 span, 81' long, riveted, fabricator unknown, Town of Genoa, Vernon County, Willenberg Road over Bad Axe River. (Current status: extant as of 8/96)

Warren, Standard, Continuous Top Chord

P-34-067 (1908), 1 standard span, 70' long, riveted, Wisconsin Bridge and Iron Company, Town of Ackley, Langlade County, River Road over East Branch of Eau Claire River. (Current status: replaced in 1989)

P-42-901 (ca. 1906), 1 standard span, 53' long, riveted, fabricator unknown, Town of Armstrong, Oconto County, Iron Bridge Road over North Branch of Oconto River. (Current status: extant as of 8/96)

Warren, Double-Intersection

P-09-718 (center span fabricated, 1907; end spans fabricated, 1914; center span moved to site from another location in 1914) 3 double-intersection spans, continuous end post and upper chord, total length 146', riveted, Wisconsin Bridge and Iron Company, Town of Tilden, Chippewa County, Ermatinger Drive over Duncan Creek. (Current status: moved)

P-14-125 (ca. 1880; moved to site in 1911), 1 span, 84' long, riveted, Lassig Bridge and Iron Works (original fabricator), American Bridge Company, Lassig Plant (additional steelwork for rebuilding), Town of Lebanon, Dodge County, Poplar Grove Road over Chicago and Northwestern Railway. (Current status: moved)

P-14-126 (1891; moved to site in 1911); 1 span, 64' long, riveted, Lassig Bridge and Iron Works (original fabricator), American Bridge Company, Lassig Plant (additional steelwork for rebuilding), Town of Lebanon, Dodge County, Scofield Road over Chicago and Northwestern Railway. (Current status: moved)

Overhead Trusses Cont'd.

Pratt Cont'd.

P-08-703 (1894), 1 span, 80' long, pin-connected, Wisconsin Bridge and Iron Company, City of Chilton, Calumet County, State Street over South Branch of Manitowoc River. (Current status: replaced in 1988)

P-09-708 (1907; moved to site from another location in 1940), 1 span, 90' long, pin-connected, fabricator unknown, City of Chippewa Falls, Chippewa County, Bear Den Drive (Irvine Park) over Duncan Creek. (Current status: extant as of 8/96)

P-09-709 (1907; moved to site from another location in 1935), 1 span, 100' long, pin-connected, fabricator unknown, City of Chippewa Falls, Chippewa County, Irvine Park Road over Duncan Creek. (Current status: extant as of 8/96)

P-09-715 (1939), 1 span, 130' long, riveted, Clinton Bridge Works (plans by Wisconsin State Highway Commission), City of Chippewa Falls, Chippewa County, Central Street over Duncan Creek. (Current status: extant as of 8/96)

P-13-190 (1897), 1 span, 124' long, pin-connected, Milwaukee Bridge and Iron Works, Town of Dunn, Dane County, East Dyreson Road over Yahara River. (Current status: extant as of 8/96)

P-38-096 (1910), 1 span, 151' long, pin-connected, Elkhart Bridge and Iron Company, Towns of Lake and Grover, Marinette County, Ferndale Road over Peshtigo River. (Current status: replaced in 1990)

P-42-042 (1928), 1 span, 90' long, riveted, Milwaukee Bridge Company (plans by Wisconsin State Highway Commission), Town of Lakewood, Oconto County, Smyth Road over North Branch of Oconto River. (Current status: extant as of 8/96)

P-42-081 (ca. 1906), 1 span, 140' long, pin-connected, fabricator unknown, Town of Stiles, Oconto County, Van Laenen Road over Oconto River. (Current status: extant as of 8/96)

P-45-700 (1888), 1 span, 109' long, pin-connected, Wisconsin Bridge and Iron Company, Village of Grafton, Ozaukee County, Bridge Street over Milwaukee River. (Current status: moved)

P-52-049 (ca. 1907; moved to site from another location, 1966), 1 span, pin-connected, fabricator unknown, Town of Richland, Richland County, County Trunk Highway AA over Pine River. (Current status: replaced in 1994)

P-57-068 (1914), 2 spans, each 113' long, riveted, Worden Allen Company, Town of Weirgor, Sawyer County, Blomberg Road over Chippewa River. (Current status: replaced in 1993)